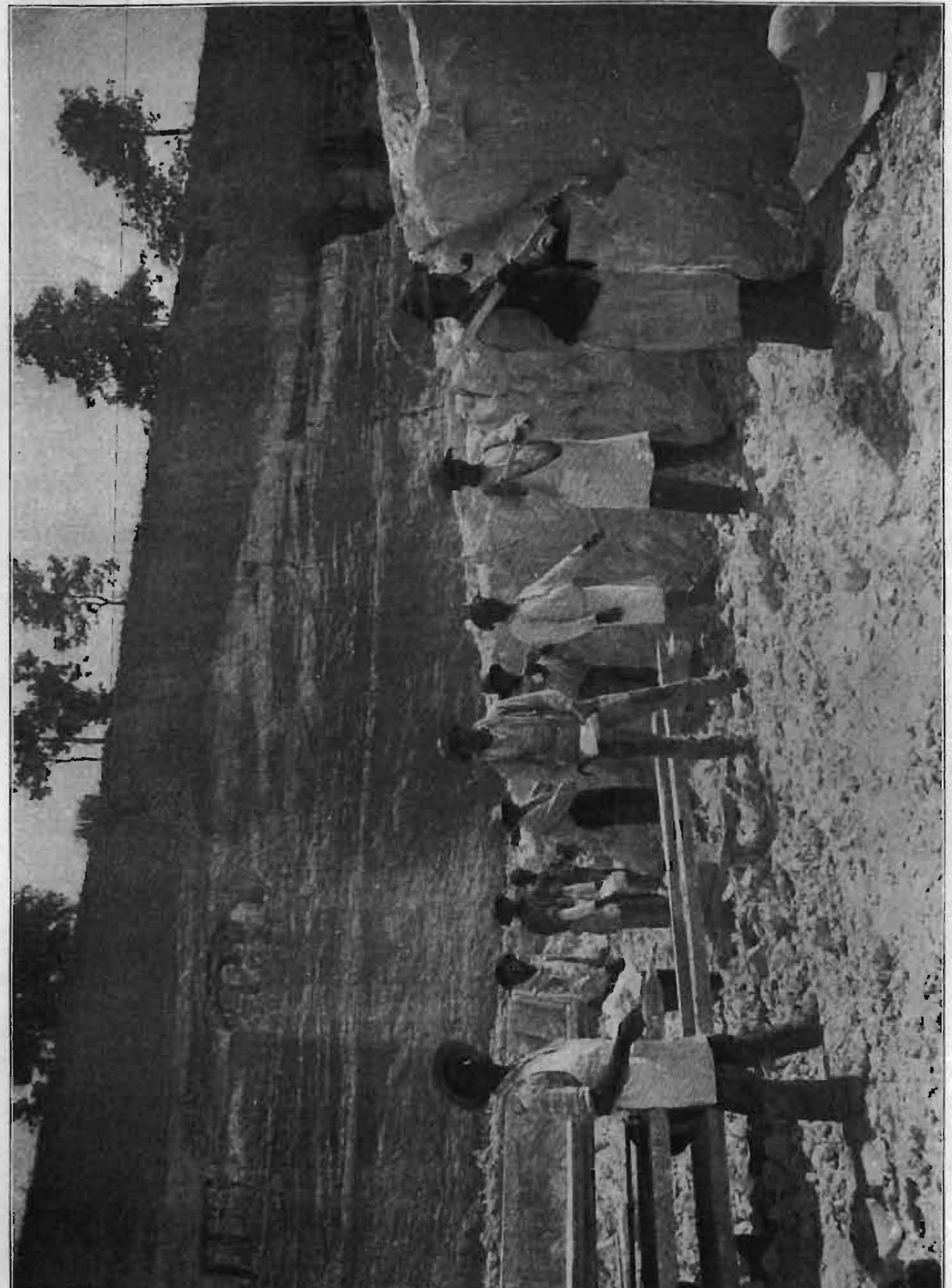
A PRELIMINARY REPORT

ON THE

Clays of South Carolina

EARLE SLOAN, State Geologist.

PLATE I.



BED OF PURE SEDIMENTARY KAOLIN—AIKEN AREA.

South Carolina Geological Survey

SERIES IV.

BULLETIN No. 1.

A PRELIMINARY REPORT

ON THE

CLAYS OF SOUTH CAROLINA

BY

EARLE SLOAN, State Geologist.

60848

COLUMBIA, S. C.
THE STATE COMPANY, STATE PRINTERS.
1904.

U.S. GEOLOGICAL SURVEY
MAR 23 1906
LIBRARY

U. S. GEOLOGICAL
SURVEY LIBRARY

LETTER OF TRANSMITTAL.

To His Excellency, D. Clinch Heyward, Governor of the State of South Carolina.

Sir: I herewith present a Preliminary Report on the Clays of South Carolina.

Hoping that it will serve to advance the material and scientific interests of this State, I have the honor to be,

Your very obedient servant,

EARLE SLOAN,

State Geologist.

January, 1904.

TABLE OF CONTENTS.

ILLUSTRATIONS.

PREFACE.

In the selection of "Clay" as the subject of systematic examination. survey, and report, I was actuated by the following considerations:

First. The very exceptional importance of the Clays as an actual and prospective resource, susceptible of greater extension and development than any mineral industry in South Carolina.

Second. The very numerous demands for information, from various States, which could not be satisfied, as nothing more than a fragmentary examination of this subject had ever been instituted.

Third. The desire of the scientific world for more definite data relating to the Clay Zone of South Carolina, with a view to differentiating the involved formations,

Fourth. The importance of stimulating a more intelligent interest in the extension of our Clay industries by outlining the technological principles controlling alike the simpler and higher ceramic arts.

In this report the qualification "preliminary" has been employed to exclude the idea of "complete" which, particularly in the case of the low grade Clays, would involve an intimate examination of every square mile of the State.

Whereas some few opportunities have been utilized to examine the Clays of the "Crystalline Region" the attention of the survey has been principally directed to the Kaolins and other Sedimentary Clays of the "Coastal Plain," which comprises the greatest accumulations of Clays of industrial susceptibilities in South Carolina.

Two survey seasons, in camp, in boat and otherwise, have been devoted to the field work, and in this report the results have been incorporated with observations derived from a previous professional association with this terrane.

Many accrued results of interest and value, not germane to the subject of this report, will be treated in a succeeding report on the Marls and Associate formations of the Coastal Plain, now in the process of preparation.

In addition to outlining the areal distributions of the Clays, their geologic horizons and genetic antecedents, I have indicated the scientific basis of their differentiation in sub-divisions, as determined by their application to the useful arts.

With summaries of the well recognized properties of Clay and the technology of its industries I have incorporated a few results of individual observation, experience and thought.

This report makes very limited identifications of localities by the names of counties, as their areas are subject to changes; the ephemeral names of railway companies are likewise omitted, their lines being indicated by the names of prominent termini. Some of the elevations indicated are hypsometric, but carefully checked excepting in the instances where qualified as approximate. The elevations given are with reference to Mean Low Tide (M. L. T.); datum line at Charleston Custom House. Some discrepancies afforded by the profiles of the different railways have been approximately reconciled.

The greater portion of the Chemical analyses incorporated in this report have been executed by the Chemical Department of Clemson College.

Some of these analyses and all of the physical and pyrometric tests have been made in my private laboratory.

Good grace requires that acknowledgements be made to the officers of the Smithsonian Institution for their very cordial professional co-operation, and to the many gentlemen of this State for their active personal interest in the work of the South Carolina Geological Survey.

The favors enjoyed through the press in stimulating individual exploitations of mineral possibilities have constituted a much appreciated factor in this work.

EARLE SLOAN,
State Geologist.

January, 1904.

MAIN SUBDIVISIONS OF THE GEOLOGICAL FORMATIONS OF THE COASTAL PLAIN OF THE ATLANTIC AND GULF BORDERS.

Aeons or Series.	Eras or Systems.	Periods or Groups.		Epochs or Stages.
CENOZOIC	Quaternary or age of MAN		Quaternary	Recent
				— (Lafayette) —
	Tertiary or age of MAMMALS	Tertiary	NEOCENE Pliocene	Floridian
			NEOCENE Miocene	Yorktown Chipola Chattahoochie
				— (Oligocene) —
			Eocene	Vicksburg Jackson Claiborne Lower Claiborne Lignitic Midway
MESOZOIC	Age of REPTILES	Cretaceous	Upper Cretaceous	Upper Greensand Middle Greensand Lower Greensand Clay marls Raritan (Amboy)
			Lower Cretaceous	Tuscaloosa Potomac
		Jurassic Triassic	Jura-Trias.	

Crystalline Region comprises underlying Paleozoic and Eozoic Series.

CHAPTER I.

GENERIC CHARACTERISTICS OF CLAYS.

In chemical technology the term "clay" is applied to an extensive group of widely distributed inorganic substances of which the determining characteristic is susceptibility of being readily molded when admixed with water, into bodies the forms of which are permanently retained after exposure to successively increased temperatures.

Heat operates first to expel the mechanically admixed water, with a temporary suspension of plasticity and retention of form; then to drive off the chemically combined water, with a permanent elimination of plasticity; and finally to produce a fractional vitrification which, through rearrangement of the molecules and the exercise of stimulated chemical affinities, produces new combinations wherein adhesion is in part replaced by cohesion, affording the clay body a comparatively homogeneous and more or less impervious texture, varying in degree with the temperature attained.

This essential quality,* in clays, of plasticity susceptible of permanent elimination, is chiefly afforded by an amorphous variety of Kaolin which in various proportions is a constituent of all clays, and therefore the basis of all "ceramic" industries, ranging in type from the simple building brick to the difficult porcelain wares.

*The flint clays, or "non-plastic fire clays," require to be ground exceedingly fine before plasticity develops. Their peculiarity is probably due to incipient recrystallization.

CHAPTER II.

GENERAL GEOLOGICAL CONDITIONS.

A consistent appreciation of any mineral body in relation to its origin and occurrence is aided by a general conception of the geological features of its environment; prefatory, therefore, to the discussion of the clays of South Carolina, we shall briefly review the more prominent geological conditions of this State.

An inspection of the physiography of South Carolina reveals two series of formations, widely differing in their topographical, structural and floral features, and separated by a meandering line, designated the "fall line," which crosses the greater streams at the head of navigation. This line, beginning at North Augusta, proceeds by Columbia and thence by Camden to the North Carolina State line, northeast of Cheraw. The area north of this line, designated the Crystalline Region, comprises the older crystalline rocks and is characterized along its upper limits by a somewhat serrated mountainous profile graduating southerly into intricately ribbed and undulating ridges with deeply sculptured valleys and rapidly flowing streams. South of the fall line we find the younger sedimentary beds, which overlap the crystalline rocks and extend thence to the sea, constituting a vast peneplain, known as the Coastal Plain, which along its upper limit characteristically affords extensive plateaus incised with deep valleys in almost abrupt juxtaposition, the included rivers having slow velocities and navigable channels.

Proceeding from the northwest part of the State along a line normal to the coast we observe distinctive zones of elevation extending approximately parallel with the coast. First the Montaine Region, with its serrated topography culminating in peaks as high as 3,500 feet above the sea level, which rapidly and irregularly declines within thirty miles to the Piedmontaine Region where the ridges afford elevations from 700 to 900 feet, and the beds of the larger streams are from 500 to 700 feet above the sea level. This "Piedmont Region" gently graduates through the middle country to the fall line, where the crystalline rocks pass under the Coastal plain formations at elevations above sea level, varying from 119 feet in the deeper valleys to 680 feet on the plateau between the Savannah and the Congaree Rivers, and 597 feet between the Wateree and the Great Pee Dee Rivers. Borings south of the fall line show the inclination of the surface of the crystalline rocks greatly increased, attaining in the Savannah area 54 feet to the mile and in the Pee Dee area fifty feet to the mile, but apparently less along the line between the two. The overlapping Coastal Plain formations, as exposed along the upper limits of their plateaus, as above indicated, attain a maximum elevation of 680 feet from which, through the intervening sand hill region, they decline within twenty miles to an elevation of 400 feet, and thence gently graduate through eighty miles of low country to the sea level at the coast.

An examination of the structural and general geological features shows the crystalline region to be constituted of rock formations more or less hard and crystalline, often pitched at high angles, folded, faulted and otherwise dislocated, and deficient in fossil remains. Proceeding from the mountains to the fall line, or along the older to the younger rocks, we successively observe gneisses, schists, slates, limestones, dolomites, quartzites, granulytes, gneisses, slates (intruded basalts), granite and shales. These rocks afford valuable structural and monumental stones, and include veins of gold, tin, lead, copper, iron, manganese, graphite, corrundum, mica, barite, limestone, talc, asbestos, feldspar, kaolin, monazite and the precious stones and other minerals.

Passing next to the Coastal Plain, we see some loosely aggregated materials without distinct stratification, and some stratified materials with a gentle dip, the latter more or less rich in fossil remains, the former rarely affording biotic evidences. We thus observe beds of subangular and rounded quartz, pebbles, gravels, arkose, sands, kaolins, and other clays, sandstones, shales, buhrstone, marls, shales, phosphate rock and coastal beds of loose shells and sand; from some of which are derived structural sandstone, kaolin, "glass sand," potter's clay, brick clay, fuller's earth, marls and phosphates.

The subdivision of these two series in South Carolina into their component systems, groups and stages is much more feasible in the case of the younger fossiliferous strata of the Coastal Plain, than in the case of the crystalline region, where in the entire asbence of biotic evidence our discriminations must largely depend upon correlation, or inferences based on the order and manner of superposition of their lithological equivalents in strata elsewhere more favorably situated for differentiation.

Kaolins and other high-grade clays therefore occur, associated with both the crystalline and the coastal plain formations. In the former they appear without reference to any particular period, being

a product of decomposition, in situ, of the generally distributed feldspathic rocks, but in the coastal plain region the kaolins representing transported sediments, of previously decomposed matter, deposited at certain definite periods, are assignable to specific horizons, and consequently knowledge of the geographical limitations of the geologic stages affords criteria on which to predicate the probability of the occurrence of kaolin or other high-grade clays in any specified area. Thus the best of sedimentary kaolins which are most extensively developed in South Carolina are assigned to the Cretaceous period, and again, our best fuller's earths extensively prevail in the Tertiary; and germane to this report is the occurrence of some other forms of clay at definite geologic horizons, to be duly noted.

While the attention of the recent Geological Survey has been partly devoted to the crystalline area, it has been in the main concentrated along the coastal plain belt as representing the most prolific source of clays. We shall not, therefore, undertake even an approximate differentiation of the members of the crystalline region in else than a general indication that the formation extending from Mount Carmel, in Abbeville County, through Greenwood, Laurens, Greenville, Union, Cherokee and York Counties, comprises the most promising probabilities of the high grade residual clays yet observed in South Carolina. The area of the crystalline formation bordering the fall line and consisting of slightly indurated argillaceous and feldspathic shales affords the meta-residual clays newly recognized as of great prospective value, and which were probably in part the original sources of the coastal plain clays.

CRETACEOUS FORMATIONS.

Immediately south of this line occurs the Cretaceous, or lowest and oldest member of the coastal plain series of formations, which in length is co-extensive with the fall line, but varies much in the width exposed. Thus its exposure begins with a narrow belt in Aiken County and increases in width as it extends easterly, affording its greatest width of exposure along the Great Pee Dee River, where it is observed with its extreme limits ninety miles apart with two extensive Tertiary gaps breaking its continuity.

There are probably no distinctive exposures of the precise equivalent of the Potomac Epoch, with its massive flora, in the Cretaceous period in South Carolina, although the result of borings admits the probability of its occurrence below the levels of the deepest valley lines in the Coastal Plain Area.

The lowest member of the Cretaceous exposed in South Carolina chiefly consists of rounded and sub-angular lumps of quartz, gneiss and slate imbedded in a crude clay matrix; beds of arkose and of cross-bedded sands with interlaminations of clay in thin layers and lenticular masses and as small pockets of kaolin; these are succeeded by gravels, sands and a series of beds of white clays varying in number, quantity and quality in the several drainage areas.

The part of the Cretaceous in which the kaolins and other white clays are intermittently observed varies from ten to thirty-two miles in width, attaining the latter along the banks of the Wateree River, and becoming again constricted at the Pee Dee River. Cretaceous marls occur along the median and lower portions of the Great Pee Dee River and along the upper part of the Little Pee Dee River.

The Cretaceous formations are intermittently exposed by the Savannah River from the Mouth of Foxes Creek to the mouth of Hollow Creek (twenty-one miles), by the Edisto River from its source to its confluence with Cedar Creek (twenty-two miles), by the Congaree River from the Saluda River to Buckingham Bluff on the Santee (thirty-six miles), by the Wateree River from Sanders Creek to Buckingham Bluff (thirty-five miles), by the Great Pee Dee River from its confluence with White's Creek intermittently to Lower Topsaw Landing (ninety-one miles), and by the Waccamaw River from the North Carolina line to Conway.

The subsidence which occurred at the end of the Cretaceous period did not operate uniformly in South Carolina, but created two depressions, the one west and the other east of a Cretaceous ridge with its axis extending between the sites of Statesburg and Georgetown. These depressions or basins which received the materials constituting the Tertiary formations were connected north of Statesburg, thereby forming to the southeast a long Cretaceous flat surrounded and partly covered by the waters of the Eocene Period—this is indicated by the fact that the succeeding Tertiary marls feather out on this ridge from which they dip westerly and easterly on its respective sides. A band of highly fossiliferous Tertiary marls extends from a point east of Statesburg southeasterly to Bostick's Landing on the Great Pee Dee; the Buhrstone formation (Tertiary) extends from a point north of Statesburg, under Statesburg southwesterly to the main body of the Eocene formation; and from the same point it extends southeasterly, but is not observed with distinctive fossils along this line until exposed by the deep incisions of the Pee Dee River.

TERTIARY FORMATIONS.

The northerly limit of the Tertiary formation, as indicated by the littoral line of the Eocene, was highly irregular, the Eocene Ocean extending its marine deposits in tongues up the bays around the promontories, and over a long shelving bottom. This littoral line is observed as we proceed from the Savannah River (near the mouth of Hollow Creek), by Aiken, near Vaucluse, by Seivern, by Horsey's Bridge (on the Edisto), up Bull Swamp, on Congaree Creek, and thence by Boykin's, Statesburg, Mayesville, Effingham, Darlington and Mars' Bluff, and into Marion County, beyond which there are no recognized Eocene beds, but the Neocene extends the shore line of Tertiary thence to the North Carolina line, where it crosses the Waccamaw River.

North of the above indicated littoral line there are some outlying patches of the Lafayette cobblestones and loams. South of this line the Tertiary formations are exposed to the verge of the ocean. The Tertiary materials comprise lignitic sands and clays, laminated siliceous clays, buhr-rock, arkose, white clays, fuller's earth, green sands, marls, clays, marls, phosphates, clays, sands, loams, cobblestones, etc., named in the usual order of seniority.

There are no appreciable beds of cobbles in the Edisto drainage area, for this region had no pronounced tributaries from the Crystalline Section, and is consequently deficient in the coarser materials that characterize the pre-Cretaceous estuarine area of the greater streams from the Crystalline Region.

QUATERNARY FORMATIONS.

Our more recent deposits occur as sands, clays, beds of shales, peats, etc., and occupy the coast area, low swamps, and other depressions which have received the comparatively recent sedimentary and marine materials. They occur in detached patches from the mountains to the coast.

COASTAL PLAIN AREAS.

There are several distinct areas of the Coastal Plain Sedimentary Clays, determined by the physiography of the several drainage areas of the early Cretaceous streams whose beds had been located and drainage areas sculptured and outlined by the dynamic forces operating during long eons prior to the Cretaceous. Thus the enormous progenitor of the Savannah River, which afforded the most prominent of these deposits, derived materials from its vast tributary area of decomposing granites, gneisses, granulytes, schists, etc., of the Montaine and Piedmontaine Region of upper Georgia and South Carolina and portions of North Carolina, where coursing with high velocity through large valleys it transported vast quantities of sediment to be successively deposited as the vast stream debouched into a wide estuarine area, to be disturbed by tides, waves and wind, and influenced by the chemical conditions of the sea. This estuarine area had its upper limit near the so-called fall line above Augusta; similarly each of the other estuarine areas found its limit near this fall line at their respective points of access to the sea. The second of these greater areas was afforded by the joint estuary of the great progenitors of the Congaree and Wateree Rivers, with their extensive drainage areas sapping the State of North Carolina for tribute to the sedimentary beds then accumulating below the site now occupied by Columbia; for at that time the coast line was not far south of the present fall line. Third in importance was the Great Pee Dee River, and then the Edisto River.

Commercially, the Aiken or Savannah River beds are of greatest consequence, and then those of the Santee, Edisto and Great Pee Dee, as sources of supply of sedimentary kaolin, the inverse order of precedence obtaining for the lower grades of clay.

Because of the geologic, chemical and physical differences separating these several areas, and for the sake of convenience, we shall treat the Coastal Plain in accordance with these sub-divisions, to wit:

The Aiken or Savannah River Area, comprising the territory in South Carolina drained by the Savannah River.

The Edisto Area, including the territory drained by the Edisto River.

The Santee Area, representing the terrane draining into the Congaree, Wateree and Santee Rivers.

The Pee Dee Area, involving the country in South Carolina drained by the Pee Dee system of rivers.

CHAPTER III.

CLASSES OF CLAY DEPOSITS.

RESIDUAL CLAYS, SEDIMENTARY CLAYS, META-RESIDUAL CLAYS.

Clay deposits are ordinarily classified as either "Residual" or "Sedimentary," in accordance with their manner of occurrence.

RESIDUAL CLAYS.

The residual clays represent residual masses of weathered aluminous matter, in situ (or at the place of origin), whereas the sedimentary represent clays transported by aqueous agencies and deposited as sediments at localities more or less remote from similar places of origin, for all kaolin (or clay) is a secondary product resulting from the weathering, or chemical alteration, of feldspars and other aluminous minerals.

The residual clays are associated with the insoluble minerals, such as quartz, mica, undecomposed feldspar and other undissolved proximate constituents which entered into the formation of the original mass of rock from which the clay was derived.

Residual deposits of clay are confined to the Paleozoic formation, lying north of the fall line, in which the crystalline rocks affording the feldspars, etc., are found.

SEDIMENTARY CLAYS.

Sedimentary deposits of clay exist in both the Paleozoic and in the formations of the Coastal Plain, the latter comprising all of the territory south of the fall line in South Carolina.

The sedimentary clays of the Paleozoic Region are predominantly of fresh water antecedents, which frequently commingled the fine silts from swollen streams of low velocity with the coarser detritus contributed through the intermittently increased velocity of these streams, or by the tributary small streams of high velocity, all resulting in the formation of low grade clays. In South Carolina the average extent of the individual deposits of the sedimentary clays of the Paleozoic Region is small as compared with that of the sedimentary clays of the Coastal Plain.

These latter were precipitated over vast shoal areas, partly from fresh water alone, but most conspicuously where salt water became mixed with the fresh. This is in part demonstrated elsewhere by the enclosure of marine fossils which could have existed only in water containing brine, but is equally potently argued by the well recognized principle determining the accelerated precipitation by salt water of aluminous matter suspended in fresh water.

I venture the opinion that the exercise of this principle accounts for the intermingling of particles of sand and the finest grained kaolin, whose widely divergent transportive co-efficients would otherwise render this association difficult of explanation. Thus we can conceive a current with its velocity diminished to the critical point at which particles of sand would settle to the bottom, which velocity would still hold the clay particles in active suspension; but admit the action of salt water, with its chemico-physical influences, and the precipitation of the fine particles of clay simultaneously with the deposition of the coarser material is probably accounted for.

We shall later invoke this principle in part to account for the irregular distribution of kaolins in the Cretaceous formation, through the varying accessions of sea water to the sandy archipelago which prevailed along this coast during the early Cretaceous, and which was characterized by vast flows of fresh water detritus from the Paleozoic Region.

The sedimentary clays of this fresh water region of the Coastal Plain frequently afford deposits of great natural purity, designated kaolin, typically exposed in Aiken County, which are due to the sortive action of the decreasing velocities of currents upon their approach to quiet waters. This action is influenced by the specific gravity, the natural sub-divisibility and, somewhat, by the shape of the respective particles derived from the residual beds.

Through this natural process of concentration, simulated in the useful arts, the quartz and other coarse-grained heavy materials are first eliminated, then the mica and fine-grained heavy particles and, finally, with arrest of current, the impalpable kaolin is precipitated.

Successive variations in the velocity of a current at a given point will cause corresponding deposits of these different materials in the same bed.*

META-RESIDUAL CLAY DEPOSITS.

Shales represent original sedimentary beds of clay which have been partly metamorphosed by pressure and heat and proportionately indurated. More advanced metamorphic action converts shale into

*With particles of similar size, specific gravity and shape, the transportive power of a current is accredited proportional to the sixth power of its velocity; and conversely the transportive power of a given current varies in a ratio inversely with the size and specific gravity of particles, and is somewhat modified by their shape.

slate with expulsion of the chemically combined water and the permanent destruction of plasticity. Shales, however, retaining their combined water disintegrate and afford excellent beds of clay. To designate these deposits Sedimentary is confusing, to term them Residual would destroy the definition provided for a residual product, in situ, of chemical action. I have, therefore, adopted the term Meta-Residual for these physically altered Paleozoic beds which are so prominently exposed in this State, intermittently along the entire fall line.

CHAPTER IV.

GENESIS OF KAOLIN.

ITS PHYSICAL AND CHEMICAL PROPERTIES—EXPLANATION OF CHEMICAL RELATIONS.

Technically, clays range in variety and composition from pure kaolin containing 39.5 per cent.* of alumina, or 100 per cent. of the hydrated silicate of alumina, to the arenaceous clays affording as little as 12 per cent. of this hydrated silicate, with less than which their adaptability to the clay industries ceases to be of importance.

The principal impurities reducing the grade of clays consist of the bases—potassium, sodium, calcium, magnesium, lithium, aluminum, iron, manganese, titanium and silicon—separately or jointly combined with one or more of their acidic co-genitors—oxygen, sulphur, chlorine, or carbon, or others, in such various proportions as to afford such proximate constituents as quartz, feldspar, mica, hornblende, augite, gypsum, calcite, alum, talc, limonite, pyrite, copperas and other inorganic (as well as organic) compounds, the character and relative proportions of which modify the texture, density, plasticity, tensile strength, shrinkage and color, and reduce the point of incipient fusion of the clays, and at the same time determine the color and texture of the ultimate product.

Thus all clays may be rationally regarded as composed of kaolin and of fluxing and other impurities whose proportions, and whose character of proximate molecular aggregation, determine the uses to which they are applied. But insomuch as some of these conditions can only be ascertained from empirical tests, there is no precise scientific basis yet available by which these several clays can be definitely classified into sharply separated varieties. All clays intergraduate.

Conventionally, clays can be classified as follows:

HIGH GRADE:		LOW GRADE:
China clay,	Kaolin.	Tile clay,
Paper stock clay,		Brick clay,
Ball clay,		Argillaceous shale,
Fire clay,		Ferruginous shale,
Potter's clay.	Fuller's Earth.	Calcareous shale.

*Some varieties of clay afford as high as 48 per cent. of alumina, which is probably due to the occurrence of the alumina as aluminum hydroxide, in the form of bauxite or gibbsite, through the influence of organic agencies.

To intelligently consider and systematically discuss the properties of clays, with reference to the scientific principles involved in their occurrence and in their relations to the industrial arts, we shall first exploit the genesis of kaolin, its composition, physical properties, affinities and distribution, as embodying in a large measure the underlying philosophy of all clay deposits.

KAOLIN (KAOLINITE).

Historical.

"The name 'Kaolin' is a corruptive of the Chinese 'kauling,' meaning high ridge, the name of a hill near Jachau Fu where the material is obtained; and the 'petuntze' of the Chinese, with which the kaolin is mixed in China for the manufacture of porcelain is a quartzose feldspathic rock."—(S. W. Williams).

Composition.

Kaolin is a compound mineral of definite proportions, known as a hydrated silicate of alumina, symbolized by the chemical formula:

$$2\,H_2O\text{—}Al_2O_3\text{—}2\,SiO_2$$

which can be resolved into:

Alumina	39.5 per cent.
Silica	46.5 per cent.
Water (combined)	14.0 per cent.

Crystal Form.

Its physical condition is in the main amorphous, but in part crystalline.

The crystals, which are microscopic, are usually in thin hexagonal or rhombic scales.

Hardness.

It varies in the scale of hardness from 1 to 2.5; it is either compact, friable or tallowy, and is generally unctuous to the feel, and adhesive.

Specific Gravity.

Its specific gravity varies from 2 to 3.2.

Color.

Its color is pure white, but in nature it also occurs grayish-white, yellowish, purple, red and black by reason of the presence of foreign coloring matter.

Origin.

The various rocks of the metamorphic series, and their igneous associates, afford sundry proximate constituents or minerals. Prominent among these rocks are gneisses, granites, granulytes, syenites, shales, dolorites, and diorites.

Conspicuous among their constituents are the feldspars—orthoclase, albite and oligoclase—which are double silicates of alumina and potash, alumina and soda, and alumina, soda and lime, respectively, and other combinations* maintaining a constant ratio of two atoms of alumina for two atomic equivalents of the single or combined alkaline elements.

The weathering, or chemico-physical alteration, of these aluminous compounds, and in a limited degree the weathering of hornblende and mica, affords sundry secondary products, the most important of which is kaolin.

As typical of this action we will consider the case of orthoclase, a prominent constituent of many granites, gneisses, granulytes, etc. Some investigators assume, with excellent reasons, as preliminary to the chemical change a molecular change in the feldspar, the hard crystalline structure becoming thereby more or less loose, friable and opaque.

Orthoclase (feldspar) is symbolized:

$$K_2 Al_2 Si_6 O_{16}$$

which represents the composition:

Silica	64.70 per cent.
Alumina	18.40 per cent.
Potash	16.90 per cent.
	100 per cent.

This double silicate, under weathering influences, slowly combines with water and is resolved into two simple silicates, to wit: The insoluble hydrous silicate of alumina (kaolin) and the soluble silicate of potash. Corresponding reactions characterize the weathering of the other feldspars and of hornblende, etc. The soluble silicates are leached-out and deported, and enter new chemical alliances, as carbonates, chlorides, fluorides, etc. The residual structure becomes, in the case of granite, a disintegrated mass of quartz particles, mica-scales and kaolin—in the case of syenite, a disintegrated mass of hornblende, mica-scales and kaolin—in the case of granulyte, a disintegrated mass of quartz and kaolin—and in the case of other feldspathic rocks, disintegrated masses of their insoluble constituents. In each of these residual beds there is observed, in addition to the constituents especially indicated, particles of undecomposed feldspar; in the case of syenite, and basaltic rocks, the somewhat similar but more gradual decomposition of hornblende, olivene, mica, etc., contributes oxides of iron and manganese which, in the absence of solvent organic agencies, become further oxidized to an insoluble state and thus appear in the residual mass. The presence of fluorine in some hornblendes possibly accounts for the occasional presence of this element in the decomposition products. The action of this element probably contributes in a relatively small degree to the alteration of the feldspars.

*Microcline, hyalophane, labradorite, andesite.

The action of carbonic acid has been invoked as of prime importance in the breaking down of the feldspars, in the origin of kaolin, through its affinity for the alkalies. Many tests instituted by Mr. Watson, and some by the writer, afforded no evidence of carbonates in the portions of the recently decomposed gneissic rocks. It is not essential, therefore, to regard the exercise of carbonic acid as of prime importance to a function satisfactorily discharged, in the opinion of some authorities, by abundantly ubiquitous water.

The breaking down of argillaceous marls and dolomites affords deposits of clay; the magnesia, lime, and any associated phosphoric acid are eliminated by the solvent action of waters charged with carbonic and organic acids. The associate aluminous matter accumulates, in situ, as clay, or is transported to enter sedimentary deposits. Some of the clay deposits observed immediately superimposed on the marls, along the upper limits of a portion of the South Carolina estuarine area, were probably thus derived from the extinguished marls whose extracted elements contributed to the phosphate deposits of this region.

Variations in the character, number, proportions and state of subdivision of the minerals observed as associated with kaolin to form clays determine differences in the physical traits at both normal and high temperatures, and in their chemical affinities at high temperatures. Thus, varying coefficients of "Plasticity," "Tensile Strength" and "Shrinkage" express the qualities displayed in the molding, modeling and preliminary drying of clays. The chemical conditions are involved in the fusion, or combination, of the basic elements with the acidic silica to form a vitrified mass at temperatures varying with the composition, or "Variety," of the clay. A brick readily fuses at the easily attained temperature (871 degrees C., 1,600 degrees F.) afforded by the common scove kiln, whereas kaolin is with great difficulty fused at the highest temperature obtainable in industrial practice, unless admixed with fluxing materials. Therefore the pyrometric conditions are important as embodying the final results of both physical and chemical conditions, on which the sub-division of clays into varieties is largely predicated. We shall therefore consider these physical, chemical and pyrometric conditions in order to properly identify the varieties and differentiate their application to their respective wares.

THE PHYSICAL PROPERTIES OF CLAY.

Color.

Naturally, clays are white, yellow, red, purple, blue, gray or black. The iron compounds color clay yellow, red, brown, blue or gray. Organic matter affords purple, gray or black colors.

Texture.

The increased degree of sub-division, or fineness, of the particles of clay and of its associate impurities diminishes the binding power, but increases absorption, plasticity, shrinkage and fusibility. In the higher grade of wares fineness of material is essential to proper fusion, for the reactions between particles are largely confined to the surface. Sub-division means multiplication of the aggregate surface area of particles, and therefore an increase in the field of action.

Extreme fineness of clays exacts great care in their drying and at the point of elimination of the combined water, which must be very gradually accomplished to avoid accumulation of pent-up vapor and steam, which tend to disrupt the clay bodies.

Water Absorption and Slaking.

In nature clays contain, in addition to the chemically combined water, mechanically absorbed moisture amounting to as much as 20 per cent. When exposed to the free access of air, the moisture content evaporates as low as 0.3 per cent.

Partly or completely dried kaolin slakes in water to a more or less perfect "slip," usually accompanied with a faint sizzing sound due to the rapid aqueous displacement of air in the capillary spaces. The rapidity and completeness of the slaking are of importance as the clay is employed in many processes in the form of a slip. The presence of organic matter somewhat increases the capacity of clay for moisture.

Plasticity.

The "plasticity" of clay expresses its susceptibility of being readily molded and modeled when mixed with water, with a retention of form until dried. The degrees of plasticity, ordinarily expressed in terms of "lean" or "fat," vary in even similar varieties. The degree of sub-division of particles, the proportion of amorphous kaolin and the physical state and quantity of the associate minerals all combine to determine the amount of plasticity.

The residual clays, where the crystalline form of kaolin most abounds, are "lean," or poor in plasticity. The Coastal Plain sedimentary clays are characteristically "fat," or high in plasticity, probably because the proportion of the amorphous kaolin predominates by reason of long exposure to dynamic forces encountered in transportation; which forces also, probably, contribute to altering the form of iron in the sedimentary clays.

Some of the meta-residual clays are highly plastic, whereas others are exceedingly lean. The latter condition is probably due to an incipient rearrangement of form, or crystallization, noted as prejudicial to the ease with which the particles can pass over each other in close adhesion. Ordinary grinding operates largely to reduce a crystal to subdivivided forms of the same crystal without greatly effecting the molecular disintegration characteristic of the amorphous condition.

Plasticity is essential, not only to the free-hand modeling, but to the self-sustaining strength of the relief parts in ornamental wares, in the green state.

The amount of water necessary to develop the maximum plasticity of which a clay is susceptible varies with its character. Thus clays require from 15 to 40 per cent. of water to effect their maximum plasticity as determined by Vicats needle.

Tensile Strength.

The tensile strength of air-dried clay (or otherwise dried at a temperature not exceeding 120 degrees C.) is popularly designated "Binding Power."

The binding power is not necessarily a functional ratio of the plasticity. Some highly plastic clays afford poor binding power. As these terms are applied, the binding power expresses the adhesive force of the dried clay; and plasticity, the adhesive force of the "green," or wet, clay. The binding power determines the amount of care to be exercised in handling the dried bodies of clay, and is highly important in resisting the strains of unequal shrinkage during irregular drying and during the burning process. The binding power must be sufficiently high to render the more or less detached portions of "high relief" work self-sustaining. This power is somewhat reduced by the fineness of the particles of the clay mixture.

Shrinkage.

Moist clays progressively shrink in the process of drying. Therefore this shrinkage is in a measure proportional to the amount of water contained. The capacity of clays for water varies with their porosity, therefore porosity determines in a measure the amount of shrinkage. A coarsely porous clay can be more readily dried than a finely porous clay of the same aggregate porosity, for it not only admits of the easier escape of vapor, steam, etc., but dries throughout with greater uniformity, all of which applies with corresponding force to the conditions of shrinkage.

CHEMICAL QUALITIES OF CLAY.

Hygroscopic Moisture.

Mechanically absorbed water occurs in all clays in their natural state. In the South Carolina clays it varies from 0.3 per cent in the air-dried to 20 per cent. in the freshly mined clay. This form of water is completely expelled at 120 degrees C., with a shrinkage in a measure proportional to the capacity for absorbing water.

Chemically Combined Water.

Chemically combined water is inherent is all clays. It occurs in the South Carolina clays in amounts ranging from 3 per cent to 14 per cent. This combined water escapes between 540 degrees C. and 645 degrees C. (1000 degrees F. to 1200 degrees F.) with an additional shrinkage closely proportional to the amount of the combined

water eliminated. At the temperature of its expulsion chemically combined water enters into combination with the sulphuric anhydride of certain alkaline sulphates and is thus in part eliminated as sulphuric acid.

Some clays high in combined water content crack upon the expulsion of this water.

Organic Matter.

Organic matter is frequently present in clays as a purple stain, which bleaches white upon exposure to sunlight. The stains in some sedimentary kaolins in South Carolina delineate in purple and pink colors the leaves of the elm, alder, cypress, willow and bay trees, and present brown colored impressions of pine and cane leaves. The most abundant form of organic matter, however, is afforded by very fine particles of decomposed vegetable tissue, constituting as much as 4 per cent. of the clay. Some of our best brick clays are highly impregnated with organic matter, yielding an advantage in obviating the necessity for adding ground coal or sand for the purpose of reducing the liability to decrepitation to which very plastic clays are subject in the process of firing. Organic matter contributes ammonia to clays. The plasticity of clays is appreciably increased by the contained organic matter.

Ammonia.

Ammonia is readily absorbed from the atmosphere by clays, and is also afforded by decomposing organic matter. It is readily volatilized by moderate heat, but as it simply occupies the interstitial space of the water, it has no effect on either porosity or shrinkage.

The dissipation of ammonia, organic matter, chemically combined water and hygroscopic water during the earlier stages of the firing process renders their chemical influence on fusibility nil.

Potash and Soda.

In the high grade clays one or both of these alkalies are present to a limited extent, but in some of the lower grade clays attain as high as 5 per cent.

Undecomposed feldspar and mica are the main contributors of insoluble potash and soda to clays. Potash and soda being the strongest basic compounds found in clays constitute their most active fluxes and are therefore prominent in reducing their point of fusion. The compound silicates of potash, soda, alumina and alkaline earths, produced in fusion, are pure white and very hard; therefore potash and soda are extensively employed in the form of orthoclase and oligoclase feldspars, in admixtures with china clays, to induce a point of fusion within reasonable attainment.

Soluble forms of potash and soda, such as the simple silicates, the carbonates, the sulphates, and the chlorides, occur in clay to a limited extent. They exercise deleterious effects on the finished wares, causing them to effloresce when exposed to moist atmosphere, resulting in white superficial incrustations.

Lime.

Calcium carbonate occurs in many clays, notably, in such as have been derived from the breaking down of marls and dolomites. It facilitates plasticity, reduces the point of fusion and counteracts shrinkage tendencies during the firing. In the form of lime it is used on the Continent as a component of glazes.

Calcium silicate, being a natural constituent of some feldspars, occurs in some clays. It is a more active flux than the carbonate. Its presence masks in a measure the presence of iron, with which it combines to form a yellow silicate in the firing process.

Calcium sulphate is found in some clays. It acts as a fluxing impurity, but is objectionable on account of its disassociation with the evolution of sulphuric anhydryde, at high temperatures, causing unsightly blisters. Both sulphate and carbonate of lime interfere with salt glazes, by reason of the efflorescent coating produced on the surface of the wares, which mechanically obstruct the access of the sublimed salt to the silica of the ware and therefore prevent the necessary combination.

Magnesia.

The presence of dolomite, or calcium-magnesium carbonate, is characteristic of those clays derived from the breaking down of dolomitic beds.

Hornblende, pyroxene and biotite, being in some cases associated with the origin of kaolin, account for the presence of magnesium silicates. Magnesium salts afford less energetic fluxes than the lime salts, its compounds are therefore more refractory.

Iron.

Iron occurs associated with clays in a considerable number of combinations, the most prominent of which are the oxides, limonite

and haematite, which respectively color the clay yellow and red. The magnetic oxide is occasionally present in small hard particles.

In the presence of organic matter iron sometimes combines to form and remain siderite, but more frequently is taken into solution under pressure as a carbonate, which again reverts to a hydrous oxide upon exposure to the air, with the effect of seriously staining the clay with an unsightly red ooze.

Iron frequently occurs as a sulphide in concretionary and other forms, and it is due to the oxidation of this pyrite that much of the clay is discolored. The presence of pyrite in many cases argues salt-water antecedents, which renders its genesis interesting, but fatal to the value of many extensive beds, notably of the (fuller's earth) clays in which it has caused the formation of alum, affording a highly objectionable flavor to oils mixed with such clays in the bleaching process. I find that fossiliferous fuller's earths are generally subject to this objection, which does not apply, however, in the case of mineral oils.

Hornblende, mica, garnet, etc., contribute iron in the form of silicates.

Several of the above named forms of iron are deposited in some clays from infiltrating waters.

Next to the alkalies some of the iron compounds exercise the most active fluxing power of any of the associate minerals of clay. In order of activity, the ferrous precede the ferric combinations, resulting in the production respectively of green and red colors and intermediate variations, dependent upon the character of the flame used in firing and upon the amount of iron contained in the clay. This discoloration of the ware is in part masked by the addition of lime, which combines with the iron, under fusion, to form a pale yellow silicate.

Alumina.

Alumina occurs in clays not only in the form inherent in kaolin, but partly through the presence of the feldspars, the micas, the dark-colored hornblendes, some forms of garnet, and other compound silicates of alumina; it also occurs in the form of aluminum hydroxide, probably as bauxite or gibbsite, and frequently in the form of alum. In the form of alumina, to which gibbsite and bauxite are brought by red heat, we find one of the most refractory materials, and one indifferent to chemical alliances in the kiln, excepting at exceedingly high temperatures. In the form of alum it induces efflorescence in the finished wares, and at high temperatures in the kiln it evolves sulphuric anhydride with blistering effects.

The compound silicates of iron and alumina contribute color to the product of the kiln. The compound silicates of alumina with the alkaline group, or feldspars, determine the possibilities of kaolin in its application to the higher form of the potter's art.

Alumina is highly refractory and indifferent to chemical combinations in the kiln, until very high temperatures are attained; but having combined with the alkalies, in the formation of feldspars, its point of fusion is greatly reduced (1310 deg. C., 2390 deg. F., representing the fusing point of orthoclase), and as feldspar it combines with clays at this temperature. But thus combined, the shrinkage from the original clay state is so excessive that it becomes necessary to add an unobjectionable corrective, which is found in silica; thus, kaolin, feldspar and silica, or "Clay," "Spar" and "Flint" in different proportions, and at different temperatures, combine in varying degrees to form the many varieties of "biscuit" characteristic of the finer ceramic wares, ranging from the (C. C.) "Cream Color" to the finest Sevres wares.

Titanium.

Titanium occurs in clays in the form of ilmenite and rutile. When in pronounced proportion, which is rarely natural, it combines with clay at very high temperatures to form a blue, enamel-like mass.

Silica.

Silica occurs in clays both combined and free, and both soluble and insoluble. This mineral is in point of quantity the predominant ingredient of all clays excepting the bauxitic clays. Silica represents 46½ per cent. of pure kaolinite, and in clays ordinarily constitutes the principal impurity.

Silicates of soda and potash, and free silicic acid are soluble in water, but occur to a very limited extent.

Ordinary methods of analysis determine silica as insoluble "free silica" or sand, and as "combined silica" such as enters combination with appropriate bases to form kaolin, feldspar, mica, hornblende, etc. Advantage is taken of the differential solubility of the silicate, kaolin, on one hand, and of the silicates, feldspar, mica, etc., on the other, to calculate the relative proportions of these minerals along lines indicated under "rational analyses."

Silica is highly refractory. Fine silica added to kaolin increases its fusibility (according to Seger) until 4.04 parts of silica shall have been added to one part of aluminum silicate (anhydrous kaolinite); but beyond this point an increase in the amount of silica results

in a proportionate decrease of fusibility. Thus, the refractoriness increases at the two extremes of the proportions of silica and of aluminum silicate.

A careful review of the chemical relations of the associate minerals constituting clay affords the following conclusions:

1. Some constitute the clay base (proper).
2. Some exercise fluxing effects.
3. Some are practically inert.

Therefore a clay should be first analyzed to ascertain its ultimate constituents, and then these constituents should be grouped to represent as closely as possible the proximate constituents, or distinctive minerals, constituting the clay, in order to calculate the excess or deficit of fluxing material and quartz for any specified ware.* These conditions give rise to the Rational Analysis, which accordingly provides for:

Clay Substance Percentage—Kaolin, incorporating such fluxing impurities as are soluble.

Free Quartz Percentage—Insoluble silica, in the form of sand uncombined with any base.

Feldspathic Detritus Percentage—Alumina, in the insoluble residue calculated as feldspar by multiplying by the connecting factor 3.51.

It is sufficient to calculate the excess of alumina over that found in the clay-base as being combined to form feldspar. This is not strictly precise, for the presence of mica and other insoluble aluminous silicates which contain alumina in different proportions should modify the amount credited to feldspathic detritus; but this affords the closest approximation that can now be devised—as is largely shown in the practical results based upon corresponding calculations. There are inherent limitations which preclude absolute precision in assigning ultimate constituents to the proximate groups constituting composite masses of minerals.

In absence of a rational analysis the ultimate analysis is usually arranged according to the following construction:

Clay Base Percentage—Total alumina calculated as kaolin.

Quartz Percentage—All silica not entering clay base (also titanic oxide).

Fluxing Impurities Percentage—Aggregate of all other bases calculated as oxides.

*Two clays might afford identical ultimate analyses and very different rational analyses, and would therefore greatly vary in their fusibilities, etc.

CHAPTER V.

PYROMETRIC CONDITIONS.

A logical appreciation of the weight of premises as related to conclusions requires in advance some competent comprehension of the conclusions in view; therefore, to systematically appraise the pyrometric values of clays, and appreciate the logic of their application in the Ceramic Arts, it is essential to formulate some knowledge of the concrete results to be attained. This necessary conception can probably be facilitated through an inspection of the generic qualities of potters' wares and the basis of their sub-divisions

Clay bodies brought to a state of incipient or partial fusion constitute the basis, or "biscuit," of all Ceramic wares.

In general terms it may be said that all Ceramic "biscuit" wares represent both opaque and semi-translucent sub-glasses, formed through the union, in partial fusion at high temperatures, of the kaolin and such bases of potash and alumina (in the form of feldspar) with the acidic silica (sand), in proportions varying with the point of fusion and the corresponding hardness of any required ware. They depart from the requirements of the true glass in not affording a chemically homogeneous mass, a part of the quartz and kaolin remaining uncombined and thereby determining the degree of opacity.

In the production of the lower grade wares many clays are self-sufficient, or afford the balance of elements essential to the required degree of fusion; but clay bodies affording the qualities required of the higher grades of ware are artificially composite—being formed by mixing different clays combining the required qualities, or by supplying to a deficient clay the required elements in the form of feldspar, sand, etc., as above noted.

Ceramic Glazed Wares, in corresponding general terms, represent biscuit wares covered with a thin vitreous coating in the form of fused glazes, or glasses, of lower fusibility than the respective biscuits to which they are applied. A few exceptions to this are found in those cases where the burning of the biscuit is advanced to the point of complete vitrification, thereby affording a glazed lustre.

CLASSIFICATION OF CERAMIC WARES.

The old English classification treated all wares as either "pottery ware" or "porcelain."

M. Brongniart, in 1858, presented a system which long enjoyed general favor; but progress has evolved varieties beyond the scope of his sub-divisions, and there is today no satisfactory or accepted scientific system of classification. So complex are the conditions, indeed, that no one consistent line of differentiation seems possible, and while we shall maintain M. Brongniart's groups, with modifications, we must depart from his sub-divisions and will add the corresponding wares, the clays used and the temperatures employed, with no other purpose than to make an instructive exhibit of the possibilities of different clays in their relations to the Ceramic wares of the present day.

Classes.	Subdivisions.	Character of Ware.	Character of Clay.	Number of Firings.
Class 1—Soft Pottery. Opaque. Soft. Porous. (Involve temperature from 1,600 °F to 2,000 °F 870 °C to 1,150 °C.)	Division 1—Unglazed. *a*. Dull. Bodies with dull unglazed surface.	*a*. Brick, drain, tile, common terra cotta, flower pots, etc.	Brick Clay	1
	Division 2—Glazed. *b*. Glossy—Fine clay body with the lustre of an almost imperceptible glaze.	*b*. Antique vessels, Greek wares, etc.	Superior brick clay	2
	c. Clear Glazed—Fine clay body with a transparent glaze.	*c*. Red Ware—Glazed crocks, cooking utensils, door knobs, spittoons, etc.	Superior brick clay	2
	d. Enameled—Enameled with opaque glaze.	*d*. Enameled brick. Tile for porcelain stoves	Dolomitic clay	2
Class 2—Hard Pottery. Opaque. Hard. Structural. Artistic. (Involve temperature from 1,700 °F to 2,300 °F 955 °C to 1,260 °C.)	Division 1—Unglazed. *e*. Sub-vitreous—Simple or composite bodies.	*e*. Floor tile, architectural terra cotta, roof tiles, paving blocks	Superior brick clay, or mixed clays or shales	1
	Division 2—Glazed. *f*. Lustrous.	*f*. Hispano Moorish Majolica	Mixed clays	
	g. Enamel or "Engobe" under Glaze.	*g*. Some ornamental brick	Potters clay	2 to 3
	h. Metallic Glaze—Metal coating over glaze, enamel or body.	*h*. Copper and silver "Metallic" Glazes—Newcomb and others	Superior brick clay	2 to 3
	i. Underglazed—Body with decorative coating under glaze.	*i*. Rookwood. Weller. Newcomb	Potters clay or mixed clays	2 o
Class 3—Pottery. Very Hard. Opaque to Sub-translucent. Sub-infusible. (Involve temperature from 1,700 °F to 2,426 °F 925 °C to 1,330 °C.)	Division 1—Unglazed and Glazed. *j*. Colored body with alkaline earthy silicate glaze, or with density requiring no glaze.	*j*. Stoneware, old gray Flemish, etc., milk and butter crocks, vitrified paving blocks, pyrites burner slabs and chemical wares	Potters clay or mixed clays	1
	Division 2—Glazed. *k*. Colored body with a transparent glaze of metallic oxide.	*k*. Yellow Ware—Bake pots, bowls, pitchers, basins, etc. Rockingham Ware—Bake pots, bowls, pitchers, basins, etc.	Siliceous Potters clay Siliceous Potters clay	2
	l. White body with transparent glaze.	. Fine Faience and Dishware—(CC) cream colored. (WG) white granite	Kaolin, ball clay, feldspar, quartz	2
	m. Slightly translucent body with transparent glaze.	*m*. Hotel China	Kaolin, ball clay, feldspar, quartz	2
Class 4—Porcelain. White Body. Semi-transparent. Very Hard. High Fusibility. (Involve temperature from 2,300 °F to 2,600 °F 1,260 °C to 1,425 °C.)	Division 1—Unglazed. *n*. White semi-transparent body.	*n*. Porcelain statuary	Kaolin, feldspar, broken biscuit	1
	Division 2—Glazed. *o*. Hard Porcelain—Kaolinitic body with a glaze mainly feldspathic.	*o*. Fine hard Porcelain.	Kaolin, feldspar, broken biscuit	1½
	p. Soft Porcelain—Mixed kaolinitic body with plumbiferous glaze.	*p*. English soft Porcelain. Early Sevres Porcelain	Ball clay, China clay, fire clay, bone ash	2
	q. Pate Tendre—Body of glass fritte with addition of clay, and a lead glaze.	*q*. French soft Porcelain, (closely allied to glassware.)	Calcareous clay, chalk, fritte	2
Class 5—Refractory Ware. Infusible. (2,500 °F to 2,900 °F. 1,370 °C to 1,593 °C.)	*r*. Unglazed.	*r*. Firebrick, tiles, etc	Fire clays, bonded with meta-residual or other clays. Some self-sufficient.	1

The results of pyrometric, or fusion, tests of clays are determined by physical standards gauging: texture (A); color (B); hardness, or porosity, (C); fire shrinkage (D); and the involved temperature (E). Pyrometric tests of clay therefore afford the crux of the calculations of results predicated on physical conditions and chemical properties. They decide as to the self-sufficiency of a clay for any useful purpose in the potter's repertoire. Many clays are self-sufficient for the lower grades of ware, whereas but few are found which fulfil all the requirements of the higher grades. Thus many clays are in themselves complete for burning into "Red," "Yellow," "Rockingham," "Stone"—and other wares; but in the production of cream colored (C. C.), white granite (W. G.) and the true hard and soft porcelains, which require successively high temperatures, it becomes necessary to synthetically construct the requisite clay bodies from materials of known chemical composition, each requiring its own peculiar proportions of clay base, fluxing material (feldspar, etc.) and silica, and such other material as may be essential to their individuality. Variation in the proportions of these parts is accompanied with a change in the point fusion and in the hardness of the resulting ware.

A large preponderance of either the "clay base" on one hand, or of the silica on the other, increases the refractoriness or point of fusion, whereas "fluxing materials" reduce this feature; hence the proportions may be varied so as to secure the degree of fusion, corresponding hardness and porosity required for any desired ware.

In practical, or empirical, tests the trial pieces thus constituted are burned in the kiln to a biscuit. Upon completion, the biscuit is given (A) the first "color inspection" to be followed by the "second" after glazing process shall have been performed. (B) The porosity of the biscuit is determined in terms of the percentage of water absorbed, this having an important relation to the capacity of the biscuit for holding the glaze before the gloss firing. If the body is too dense it will not properly absorb the water from the slip in which it has been immersed and consequently the slip peels off. (C) The biscuit is measured for fire shrinkage, which expresses variation in its dimensions as compared with its size in the clay state. Excessive fire shrinkage condemns the original mixture, which must be corrected accordingly, quartz being employed for this purpose by reason of its property of swelling at high temperatures and thereby counteracting shrinkage.

The biscuit trial piece is next coated with glaze by immersing the piece in a liquid slip, it is then exposed in a glost furnace at a lower heat than the biscuit burning required, with a view to developing two features:

First. To ascertain whether the glaze develops any color not revealed in the biscuit stage—the glazes being much more solvent of iron in certain proximate forms than is the biscuit, and, as previously recited, chemical analysis failing to discriminate precisely these proximate forms, unless susceptible of mechanical separation. The identical percentage of iron which in certain forms can be admitted without prejudice will in other forms be dissolved by the glaze and afford objectionable color.

Second. To determine, upon cooling, whether the shrinkage of the biscuit and that of the glaze conform, as otherwise "crazing," or cracking of the glaze, or "shivering" of the ware will ensue; the latter resulting from the fact that both the shrinkage and tensile strength of the glaze are greater than the corresponding qualities of the biscuit.

All of these tests of trial ware are conducted to the best advantage in the kilns employed in the production of the corresponding ware on a commercial scale, where the actual environments of gases, dust, etc., are brought to bear; but good approximate tests of value are made in the regular test furnaces. If the results of the empirical tests seriously depart from the calculations based upon the physical and chemical conditions of the clay body, it becomes necessary to make supplementary changes in the proportions or even in the character of the materials employed.

To calculate the points of fusion of "clay bodies" reference is required to their rational analyses; but we will first review the practical observations on which these estimates are based, and partly analyze their controlling principles.

1. The finer the degree of sub-division of the particles of a clay body the more readily will they enter fusion, by reason of the increase in the field of action.

2. Ceramic Biscuit Ware can be viewed as opaque or sub-translucent approximate-glasses formed through the incipient union of the acidic silica with the basic alumina, potash, etc., of feldspar, and in part with the alumina of the kaolin, in proportions of sundry fusibilities. These fusibilities are in a measure proportional to the total fluxing impurities, modified by the differential fusion intensities of the included bases. Thus the refractoriness of clay is reduced by the

presence of compounds of potash, soda, iron, lime and magnesia, named in the order of greatest fusion intensity; and the relative proportions of alumina and silica must also be considered. All of these conditions are involved in the following observations:

Kaolin is highly refractory, being practically infusible.

Silica is highly refractory, being practically infusible.

Feldspar (orthoclase) fuses at or about 1310 degrees C., (F. 2390 degrees.)

(A) Kaolin and Feldspar.—The refractoriness of kaolin can be reduced by the addition of feldspar until sufficient is added to combine in a large measure with the kaolin, forming the sub-vitreous, semi-translucent mass typical of hard porcelain.

(B) Kaolin and Silica.—Refractoriness due to an excess of kaolin can be reduced by increasing the amount of fine silica to 3.47 parts of silica to one part of kaolinite, fusing at 1620 degrees C., equal to F. 2957 degrees (represented by the formula $Al_2O_3\ 17\ SiO_2$)* beyond which point an increase of the proportion of silica steadily increases the point of fusion.

The converse is obvious, refractoriness due to an excess of silica can be reduced within the corresponding limit by the addition of kaolin. The temperature involved in this fusion is too high for attainment on a large scale, but is available on the scale employed in the manufacture of artificial teeth.

(C) Kaolin, Silica and Feldspar.—These materials, in a mixture approximately representing the equivalent masses of (A) and (B), afford a still further reduction in the refractoriness through the formation of compound sub-silicates of lower fusibilities. Such mixtures find their equivalents in the artificial mixtures required for fine faience wares—(C. C.), (W. G.) etc.

(D) Kaolins, Silica, Feldspar and additional fluxes.—The point of fusion of the mixture represented under (C) is reduced by an increase in the proportions of fluxing alkalies, or alkaline earths, or iron compounds, the respective equivalents of which are found in nature in "Potter's Clays," "Dolomitic Clays" and "Brick Clays."

Kaolin and such materials as are usually or artificially mixed with it, in serviceable proportions, constitute the Potter's "Clay Body."

This "body" having been subjected to the usual perliminary mechanical treatment is next molded or modeled, and is then dried and

*Seger.

placed in a kiln, with the following physical indications of change and corresponding chemical alterations:

1. All absorbed moisture is expelled below 120 degrees C., equal to F. 248 degrees. The clay body shrinks progressively with the expulsion of water, and in a measure proportional thereto.

As the temperature increases there is no further expulsion of gases, unless ammonia be present, until we approach the temperature of 537 degrees C., equal to F. 1000 degrees, from which point to 648 degrees C., equal to F. 1200 degrees, the elimination of chemically combined water is effected, accompanied with the escape of carbonic acid gas and sulphuric acid if compounds of these acids are present. The organic matter is at the same time oxydized or otherwise destroyed. The clay begins slightly to soften and contract, partly closing the pores which were voided by the eliminations above indicated. This softening naturally starts at the surface, and in the case of very fine-grained bodies requires the exercise of great caution in holding the temperatures comparatively steady until all gases are thus eliminated, for the reason that the surface becomes somewhat dense, or pasty, and thereby restrains the escape of gases, which causes a bloating of the mass.

With advance of heat the points of "Incipient Fusion," "Vitrification," and "Viscosity," or fluidity, are successively attained at temperatures varying with each variety of clay and even with species of the same variety. This variation is an important factor, especially in its relations to brick burning, where the greater niceties in the control of temperature are impracticable. Consequently, if the margin between incipient fusion and viscosity is small the danger of overburning the ware generally induces the fault of underburning, with prejudice to such hardness and imperviousness as may be required, for incipient fusion implies increased hardness and imperviousness. These qualities are successively increased in the vitrification and viscosity stages. At the point of vitrification of some clays the further disassociation of sulphuric anhydride from its salts is evidenced by unsightly blistering of the ware.

The character of the flame in a kiln exercises reducing or oxydizing effects, according to the predominance in the furnace gases of uncombined oxygen on the one hand and of unsatisfied carbon on the other. Where, then, materials of the clay body are susceptible of two or more degrees of oxydation, as in the case of iron, and the salts corresponding to these respective degrees of oxydation afford different coefficients of fusion, the character of the flame will determine the degree of oxydation, and therefore influence the point of temperature at which these iron compounds will enter fusion. Where the increase in temperature is rapid the reducing or oxydizing effect does not extend much beyond the surface and consequently the surface and core of a brick, or other dense mass of clay, will not only enter different degrees of fusion but afford a variation in the colors corresponding to the degree of oxydation.

A study of the principles underlying the observations relative to the conduct of a clay body exposed to successively high temperatures has given rise to several methods of calculating the point of füsion which are based on the quantitative relations of the clay-base to the silica and fluxing materials as revealed by a "Rational Analysis." Thus Bischof's rule provides that the refractoriness of a clay shall be considered proportional directly to the square of the alumina and inversely to the silica and fluxes present. This is based on the assumption of equivalent fineness of material, which in practice cannot be relied on. Others have employed the "Oxygen Ratio," or quantivalent ratio of the oxygen combined in the silica (and other acids) to the oxygen combined in the magnesia, lime, iron, alumina, and other bases present in the clay body, thereby regarding all silica and other acids as combining with the bases without differentiating the varied fusion intensities of these bases and without discrimination as to the size of the particles. This system affords suggestive approximations. Wheeler's System is the only one which applies with approximate accuracy to practical conditions, by introducing a factor of correction determined by the size of the particles of material.

Reliable practice provides for determination of the fusion point by actual furnace tests, the temperature being measured by pyrometric instruments, or by trial pieces of clay of established points of fusibility. This latter system, devised by Seger, is applied through the introduction of small triangular pyramids of the requisite composition, known as Seger's pyramids. These pyramids soften in a furnace as the temperature reaches their respective fusion points, which is indicated for each by its tip bending to the level of the base. The pyramids are designated by numbers ranging from 022 to 36 with corresponding temperatures from 590 degrees C., equal to 1094 degrees F., to 1850 degrees C. equal to 3362 degrees F. In the appended table* it will be observed that these pyramids, or cones,

*Seger's.

increase from 022 to 010 in units equal to 30 degrees C. each, whereas from 010 to 36 the units are equal to only 20 degrees C. This system of determining temperatures is considered sufficiently accurate for practical purposes.

FUSION TEMPERATURES BASED UPON RECENT RECALCULATIONS FOR SEGER'S PYRAMIDS.

No. of Cone.	Fusion Point. Cent.	Fusion Point. Fahr.	No. of Cone.	Fusion Point. Cent.	Fusion Point. Fahr.
022	590	1094	8	1290	2354
021	620	1148	9	1310	2390
020	650	1202	10	1330	2426
019	680	1256	11	1350	2462
018	710	1310	12	1370	2498
017	740	1364	13	1390	2534
016	770	1418	14	1410	2570
015	800	1472	15	1430	2606
014	830	1526	16	1450	2642
013	860	1580	17	1470	2678
012	890	1634	18	1490	2714
011	920	1688	19	1510	2750
010	950	1742	20	1530	2786
09	970	1778	21	1550	2822
08	990	1814	22	1570	2858
07	1010	1850	23	1590	2894
06	1030	1886	24	1610	2930
05	1050	1922	25	1630	2966
04	1070	1958	26	1650	3002
03	1090	1994	27	1670	3038
02	1110	2030	28	1690	3074
01	1130	2066	29	1710	3110
1	1150	2102	30	1730	3146
2	1170	2138	31	1750	3182
3	1190	2174	32	1770	3218
4	1210	2210	33	1790	3254
5	1230	2246	34	1810	3290
6	1250	2282	35	1830	3326
7	1270	2318	36	1850	3362

GLAZES.

"Ceramic Glazed Wares" represent biscuit wares covered with a thin coating of glaze, or glass, of lower fusibility than the biscuit to which it is applied.

These glazes therefore vary in composition with the character of the biscuit.

The simplest glaze applied to some earthernwares and to some stonewares consists of a silicate of soda formed by the action of volatilized sodium chloride (common salt) on the siliceous surface of the highly heated ware. Other glazes are applied in the form of slips in which the wares are "immersed;" in some cases the wares are "watered," the slip being poured over the biscuit; again the dry powdered glaze is blown or "dusted" over the moist surface.

The ware is then dried and placed in the Glost Kiln and heated to the temperature required for the fusion of the glaze.

The slip glazes comprise several types; the simplest of these is the "Albany Slip," a highly fusible clay supplied from New York, which is chiefly applied to stoneware.

The simple lead glazes, or mixtures of lead, silica, boracic acid, alumina, etc., which are readily fusible, are applied to the faience wares and other wares requiring glazes of high lustre.

Finally, for the hard porcelains finely ground feldspar is applied in the form of a slip—the porcelain being first partly baked to develop the porosity essential to the adhesion of the slip to the body.

These glazes are designated "Raw;" others, known as "Fritted," are produced by first mixing the ingredients, fusing them in a crucible, reducing to fine powder, forming a slip, and applying accordingly. The object of "fritting" is to ensure the proper combination of alkaline earths, which require for combination higher temperatures than the wares would stand, to prevent solution of the alkalies, borax, etc., in the process of water grinding; and furthermore to effect combination of these alkalies and borax with the silica and thereby prevent volatilization, to which they are subject at high temepratures when uncombined.

The glaze must be so constituted as to conform to the required transparency and color and be without undissolved particles of its constituents.

It should distribute itself uniformly and adhere to the surface of the ware in burning.

Its coefficient of shrinkage must conform to that of the body of the ware, as otherwise the glaze will be cracked, or "crazed," or, if

its tensile strength is superior to that of the biscuit, it will in contracting on the biscuit "shiver" the ware.

It must have sufficient alumina to correct the devitrifying tendency of long exposure to high temperatures. Where a ware is to be decorated with metallic oxides, etc., the glaze must be so proportioned as not to combine too actively with these materials, as such action results in the running of the colors. There is no stage in the process of the manufacture of Ceramic Wares where the services of a skilled chemist can be more advantageously employed than in the determination of the proper glaze for any particular ware.

CHAPTER VI.

VARIETIES OF CLAY.

THEIR PROPERTIES, USES AND DISTRIBUTION.

HIGH GRADE.		LOW GRADE.
China Clay,	Kaolin.	Tile Clay,
Paper Stock Clay,	Kaolin.	Brick Clay,
Ball Clay,	Kaolin.	Argillaceous Shale,
Fire Clay,		Ferruginous Shale,
Potter's Clay.	Fuller's Earth.	Calcareous Shale.

The word Kaolin, derived from the Chinese, implies the plastic aluminous body from which china-ware is made.

Some writers undertake to limit the term kaolin to material extracted from residual deposits, although many of the sedimentary deposits with the same ultimate origin afford a higher percentage of this material, some conforming almost exactly to the composition of pure kaolinite, and both the residual and the sedimentary clays are used in the manufacture of china-ware. The distinction is an arbitrarily attempted trade assumption which with many finds no proper scientific justification. The English qualification "Ball Clay," which expressed a highly plastic kaolin, some have undertaken to make generic in its application to the sedimentary deposits although some of these beds are no more plastic than the residual beds.

Mr. Tuomey in this State applied the term to both residual and sedimentary deposits, and Mr. Dana a half century later concurs in this practice.

The paper stock clays are white plastic kaolins of either residual or sedimentary extraction which, upon burning, either cinder or develop color or other incorrigible defects unsuiting them to the Ceramic Arts.

White ware kaolins comprise china clays and ball clays. These two clays, which contribute respectively white body and plasticity, are incorporated with quartz to resist shrinkage, and feldspar to control the fusibility, in such proportions as their rational analyses may suggest. They occur both in the residual and sedimentary beds of South Carolina.

Residual and sedimentary kaolins adapted to the requirements of the white wares vary from slightly fusible to highly refractory,

according to the amount and nature of the fluxing materials present. Their combined point of fusion in mixtures must not be below the fusing point of the glaze to be applied. Their color must be white or of such variations as are due to organic matter, which is dissipated under high temperatures without serious effect upon else than the shrinkage, which it increases.

The percentage of iron permissible without prejudice to the clay body varies with the size of the particles and the character of its form or mineral aggregation. The ferrous (or protoxide) salts are much more fusible than the ferric (or sesquioxide) salts, and the affinities of the respective oxides vary accordingly. The action of organic matter predisposes the presence of the protoxide of iron, but the action of the furnace gases, according as whether oxidizing or reducing, makes these forms of oxide readily inter-convertible. In the form of small, hard grains of the anhydrous oxide it is the least objectionable, as in this condition it enters with more difficulty such combinations in the furnace as diffuse color throughout the mass, probably remaining principally as small isolated grains not readily discernible to the naked eye. In this form its presence in amounts as high as 1.5 per cent. may occur without serious prejudice. This is the condition of the iron chiefly occurring in the residual kaolin, but not exclusively so. If, however, small grains of the hydrous oxide are present they enter combinations in limited spheres, causing splotches, etc.; the expulsion of the water of combination renders the particles porous and therefore more easily reduced, and consequently on both physical and chemical grounds more subject to the solvent action of the partly fused silicates in immediate contact with them. If the iron oxide occurs in the loosely aggregated form of an ooze or slime (with the fineness of fresh chemical sub-division as newly derived from the alteration of pyrites or other forms) it is probable that its susceptibility to combination is increased. If the iron occurs combined with the alumina (as a finely sub-divided compound iron-alumina-silicate formed through the action of a solution of iron carbonate on the alkaline silicates) its diffusion is promptly revealed in the furnace by yellow coloration, one of the characteristic evidences of the presence of iron in a silica-soluble form. This is the form of iron which chiefly obtains in the sedimentary kaolins of the Coastal Plain, where the action of organic matter on the sulphates of the sea water in the presence of iron probably determined the occurrence of pyrites which is altered by organic influences to the successive forms of carbonate, hydroxide, etc. In this form the percentage of iron should be less than 1 per cent., determined as oxide.

RESIDUAL KAOLINS.

The residual kaolins, as concentrated for the trade, vary from moderately fusible to highly refractory according to the amount and character of the fluxing impurities. These consist principally of feldspar and more or less decomposed micas, garnets, etc. Quartz constitutes, however, the most prominent impurity. These impurities, which frequently exceed 80 per cent of the whole, are partly eliminated by a preliminary sorting or "culling out" of the large lumps of quarts and feldspar, and by washing or concentrating the kaolin by taking advantage of its superior transportive power in water because of its greater fineness and lightness. The residual kaolins are, as a rule, of inferior plasticity and tensile strength, the latter rarely exceeding fifty pounds, and probably averaging about fifteen pounds to the square inch. Residual china clays vary in the percentage of contained clay substance from fifty to one hundred; they undergo a combined air and fire shrinkage exceeding in some instances 15 per cent, but ordinarily average 10 to 12 per cent. The point of incipient fusion ranges from 1204 degrees C. (2200 degrees F.) to a temperature above 1815 degrees C (3300 degrees F.), depending upon the purity of the kaolin; kaolins of the lower fusibility being used for the ordinary white wares, or mixed with the higher grades of kaolin for the porcelain wares.

No residual deposits of kaolin have been commercially developed in South Carolina, and whereas there are many indications of such veins scattered throughout the granitic or crystalline region the occurrences of most conspicuous promise yet noted are along a zone, in close proximity to the trappean rocks, extending from Mount Carmel to King's Mountain; the dynamic influences of these igneous rocks probably predisposed the feldspar, etc., to rapid kaolinization through allotropic modifications.

SEDIMENTARY KAOLINS.

The sedimentary kaolin beds in South Carolina range in purity from 99 per cent. of clay substance to the lowermost grades. Its fluxing impurities comprise potash, soda, iron, lime, magnesia, etc., more or less combined with silica in amounts varying from mere traces to the limits of fatal defects. These impurities occur as quartz, feldspar, mica, hornblende, limonite, pyrites, etc.; its fusibility varies accordingly. In tensile strength sedimentary kaolins vary from three pounds to exceeding one hundred pounds per square inch; in combined air and fire shrinkage from 1 to 30 per cent. The point of incipient fusion varies from above 1815 degrees C., 3300 degrees F. down to 1204 degrees C., 2200 degrees F. The peculiar form of its iron content as compared with that of the residual kaolin, limits in part its more extensive substitution for the latter. Some sedimentary clays, however, fulfill the conditions of china clays, in being lean and in burning to a white body without crazing or displaying other physical defects. Plastic sedimentary kaolins, or ball clays, are mixed with the lean residual clays, or other china clays, to increase their plasticity. The amounts of the ball clays added vary from one-third to two-thirds of the amount of the china clay, according to the degree of color permissible; the greater amount of the sedimentary kaolin increasing the color of the biscuit or glaze ordinarily, but not invariably. In South Carolina there are extensive beds of pure white sedimentary kaolins exceeding eighteen feet in thickness and affording 98 per cent. of clay substance, which requires no other preparation than drying. (In Florida sedimentary beds of kaolin are worked to advantage, which carry 75 per cent. of foreign matter, which is eliminated by washing, and these beds contribute extensively to the supply of plastic kaolin.) The sedimentary kaolins of South Carolina occur in deposits, the extent and purity of which challenge comparison with any known beds. They underlie vast areas of the Cretaceous and Eocene terranes, offering themselves for utilization wherever the process of erosion or other degradation has sufficiently removed the overlying beds of Eocene and Neocene clays and sands. Whereas these beds are in some places practically continuous for several miles, the whole is sub-divided into isolated areas with extensive intermediate barrens.

These kaolins are extensively distributed in the Savannah River Area, the Santee Area and the Edisto Area, in the Counties of Aiken, Lexington, Richland and Kershaw. The Savannah river Area affords one of the most remarkable exposures of sedimentary kaolin in the United States, not only in its relations to quality and quantity, but in the scientific interest attaching thereto. From Hamburg to Aiken we observe a zone of these clays extending fourteen miles in length by five miles in width, with numerous barrens caused by pre-eocene erosions and the degradations of recent drainage.

These beds of kaolin vary from five to twenty-five feet in thickness, with an overburden of cross bedded sands, thin laminae of clay and occasional Lafayette loams and cobbles ranging in thickness from nil to more than one hundred feet. The thickness of the kaolin determines the amount of overburden that can be economically removed. This overburden is degraded by laborers with pick, shovel and cart, or with scrapes or steam shovels, until a sufficient terrace of clay is bared for extraction. This kaolin is moved in the lump form to the dry sheds, where, after exposure to air and light for a few weeks, it is packed in casks of one ton capacity and shipped to the consumer. It probably represents the largest body of clay closely approximating kaolinite that is found in the United States.

The Aiken Area also affords important deposits along Beaver Pond Creek and Hollow Creek.

The Edisto Area reveals interesting beds of these clays on North Edisto River, between Cook's Bridge and Merritt's Bridge and along Fox Creek; superior deposits along the South Edisto River, along Chalk Hill Creek, Juniper Creek, Marbone Creek and near Sand Dam Bridge.

The Santee Area reveals valuable beds along Thom's Creek, Cedar Creek, Colonel's Creek, Shaw's Creek, Swift Creek, Rafting Creek and Pine Tree Creek, and in some places adjacent to the Congaree and Wateree Rivers.

In addition to the foregoing class, which requires no other preparation than simple drying, there are considerable beds of cretaceous clays commingled with sands which are susceptible of concentration by the usual washing process. There is a modern plant for such purpose in operation at Seivern, S. C.

The class of clay indicated, Middendorf, prevails in large beds in the Aiken, Santee and Pee Dee Areas. In color they are very pale greenish-yellow, but burn to a white body with quite variable shrinkage. Their tensile strength is superior to that of the whiter clays. Their extreme fineness of particle renders them much more fusible than other clays similar in composition but coarser in texture.

WOOD PULP KAOLIN.

Many of the sedimentary kaolins occurring as described in the preceding paragraph are by reasons of their previously noted limitations devoted to the manufacture of wood pulp paper. In the manufacture of the varieties of wood pulp paper used

for newspaper, and other purposes, the kaolin known as paper stock clay enters to an extent, varying from 15 to 25 per cent. of the whole, the balance being composed of ground pulp, cooked pulp and resin, in such respective proportions as 53, 17 and 5, all of which are incorporated in the cutter as a fluid pulp, the clay having first been slaked to a "slip." The ground pulp is of short fiber, and affords the cheaper body which is strengthened by the addition of the long fiber of the cooked pulp, the whole being cemented by resin which also contributes to the gloss, and sized by the clay which fills the interstices. Much of the clay is added, however, to give weight. The market value of the clay is about $8 per long ton, delivered at New York, while the market value of the paper ranges from $50 to $60 per ton. The early deterioration of this paper is attributed in the main to the presence of the resinous matter, which affords a nutrient for fungoid growths, the albuminoids of the ground fiber also contributing to this evil. Kaolins of high densities are chiefly in demand for this purpose, for the reason that they afford a superior surface to the paper, and for the further reason that pulp with a fixed volume of space between its fibers will absorb more weight of kaolin of high specific gravity than the same volume would represent in kaolin of low specific gravity. A clay of such density as will be retained in the fiber to the extent of 65 per cent. of the amount of clay present, when squeezed through the first rolls, is considered good paper stock clay, although some clays appreciably exceed this limit. It is required that the clay shall be white, for both white and colored papers, for the reason that the tints of nature in kaolins are perishable if of organic origin, and irregular if of a mineral nature. The manufacturer prefers to add a fixed amount of definite pigment to the white clay to insure uniformity and constancy of such color as may be required. The substitution of this clay for starch in sizing the cheaper cotton fabrics is rapidly obtaining, the advantages to the seller being obvious. South Carolina supplies about 35,000 tons of such clays each year to the Northern market. This entire paper stock output is derived from Aiken County.

As indicated in what has been said of ball clays, such plastic white clays as do not afford satisfactory furnace tests are relegated to the paper maker; but the paper maker receives a great deal of clay suited to the Ceramic Arts through the reluctance of an occasional potter to depart from his accustomed clays and recipes, and, I regret to recite, because of a disposition not to admit the virtues of clays which if recognized might beget competition. There is, however, a large and ever increasing number not of this class, but broadminded, intelligent, progressive and ever eager to increase the field of their supplies. The tests made by such men have a signal value and have no doubt reclaimed to their uses many neglected deposits.

FIRE CLAYS.

Clays adapted to the manufacture of refractory articles are known as fire clays and are ordinarily subdivided into flint clays and plastic fire clays.

There are no flint clays in South Carolina, these clays belonging to the coal measures. All flint clays are not refractory. Those which afford the required refractoriness being very deficient in plasticity require the addition of plastic fire clays, such as are found in this State. Some flint clays closely approximate the composition of kaolin.

One of the most noted fire clays is from Mount Savage, and affords the following characteristic analysis:

Clay substance	78.00 per cent.
Quartz impurities	18.00 per cent.
Fluxing impurities	4.00 per cent.
	100.00 per cent.

While we have none of the flint clays we have in point of composition their equivalents, with the advantage of good plasticity, notably among some of the Cretaceous deposits; but in many instances the extreme fineness of the particles tends to lower their fusibility by an amount exceeding 111 degrees C. or 200 degrees F., as compared with clays of similar analyses but coarser in texture. The equivalents of the plastic fire clays, combining the refractoriness of flint clays, we have in the lower Cretaceous formations, ranging in composition from the common grades to the best imported German product.

The highly refractory clays and the plastic fire clays are ordinarily mixed in proportions varying from 25 to 75, respectively, or reversed according to character of the ware required, to which is added as high as 50 per cent of sand, or preferably "grog" (burnt fire clay), to correct excessive shrinkage and insure a certain amount of porosity. The shrinkage of fire clays varies from 1 to 25 per cent., their tensile strength from five pounds up to the high limits involving

such plasticity and consequent absorption of water that the semi-wet process is required for their treatment in order to reduce the tendencies of excessive shrinkage and cracking. Fluxing impurities in excess of 4 per cent. are prejudicial to refractoriness.

We have in South Carolina not only extensive beds of superior fire clays, but suitable clays for the sub-refractory wares not requiring more than 1400 degrees C. temperature, at which these clays are self-bonding, through incipient vitrification; they serve well the requirements of all ordinary furnaces. But, for the minimum limit ordinarily accepted as refractory, 1490 degrees C., it becomes necessary to mix a highly refractory clay with enough of the more fusible clay, of the same approximate co-efficient of shrinkage, to thoroughly bond together the infusible particles of clay and quartz, or grog, etc., without prejudice to the required degree of porosity. The ware should be porous, to facilitate ready and uniform adaptations of the entire mass to the frequent changes of temperature to which it is ordinarily subjected; otherwise cracking will ensue. It should be so bonded with a matrix as to resist the required compression, varying with the uses to which the ware is applied. A refractory ware should be burnt to a temperature as high as will be required of it in actual service, in order to preclude such further vitrification as might involve additional shrinkage with the accompany disarrangement of arches or other structures into which they enter.

Fire brick which are to be exposed to acid gases should be highly siliceous, such being required in the case of pyrites burners, etc., whereas fire brick intended to be subjected to the action of alkaline dusts, ashes, etc., at high temperatures, should be basic, as in the case of boiler furnaces, etc.

The sedimentary fire clays of South Carolina are found in the Cretaceous, the Eocene and the Neocene formations, along the zone contiguous to the fall line. Some beds of fire clay of unmistakable sedimentary origin and others of meta-residual extraction are found in the crystalline area. These meta-residual clays are employed to bond the more refractory clays and the Middendorf sedimentary beds should be serviceable for the same purpose.

STONEWARE CLAY AND POTTER'S CLAY.

These clays vary in composition, as determined by analyses, within the following approximate limits:

Clay base from 50 to 75 per cent.

Sandy impurities from 30 to 45 per cent.

Fluxing impurities from 3 to 5 per cent. for stoneware.

Fluxing impurities from 5 to 10 per cent. for yellow ware.

Moisture from 1 to 3 per cent.

They will thus be observed as representing successive gradations between fire clays and tile clays, the fire clays extending the gradations upward to the limits of kaolin.

The distinction between stoneware clay and potter's clay, used for yellow ware, etc., depends on the difference of fusibility. In the manufacture of stoneware the clay body is burned to vitrification (and is thus used), or in the same operation it is both vitrified and glazed, the Albany slip or other clay glaze having been applied to the green body. In the case of yellow and Rockingham ware the clay body is burned to a biscuit, affording its maximum physical strength and toughness, and is then drawn and covered with a lead glaze, after which it is given at a lower temperature a gloss burning to fuse the glaze. It is therefore more economical to employ clays of lower fusibility than are required for stoneware, although this practice is not invariable. Many clays are self-sufficient for stoneware and for yellow ware, but in most cases mixed clays are required.

A stoneware clay should be reasonably plastic, excessive plasticity always involving greater energy to constrain it to desired forms.

Stoneware clay should have a tensile strength of 100 pounds to the square inch, although it is worked as low as 35; it should not undergo a combined air and fire shrinkage exceeding 15 per cent.

There must be a fair margin between the temperature necessary for vitrification and the point of viscosity, in order that the ware may be sufficiently vitrified to render it impervious without danger of prejudice to its strength and shape by viscosity. A good stoneware clay body should vitrify at a temperature of about 1150 degrees C., equal to 2100 degrees F., with a margin of 150 F. degrees for viscosity. It should burn through a uniform yellow at incipient vitrification, to stone gray at a stage short of becoming brittle.

Potter's clays for the manufacture of yellow and Rockingham wares should be smooth, reasonably plastic, and fuse at a moderate heat, burning to a pale yellow or buff color. They should contain sufficient iron in the proper form to afford a uniform color. As previously noted, they ordinarily contain more of the fluxing impurities than the stoneware clays into which they graduate at their lower limit, the upper limit being represented by 10 degrees of fluxing matter. It is found advantageous to weather these clays in order

to facilitate pulping in connection with the washing process, in which they are reduced to a fineness exceeding 60 mesh to the inch. They should be reasonably plastic.

Throughout the Crystalline Region we observe occasional patches of both residual and sedimentary clay suitable for the coarser grades of potter's ware, the best results are secured by mixing the residual or meta-residual clays with the Coastal Plain sedimentaries, which are abundantly available for this purpose. There is an extensive body of clay near the top of the upper Cretaceous observed in Aiken, Santee and Pee Dee areas, which has not hitherto been utilized, that is eminently fitted not only for these wares but should have been and will be utilized for the finer faience wares. In some localities two beds occur, one over the other, separated by about twenty feet of sands, the clay body aggregating from ten to forty feet in thickness. Whereas these clays are higher in clay base and lower in fluxing matter than is specified for the potter's wares, the extreme fineness of the particle renders them much more fusible than corresponding clays of coarser grain.

SEWER PIPE OR VITRIFIED BRICK CLAYS.

The following are the approximate limits of the constituents of these clays as determined by analysis:

Clay base 45 to 60 per cent., with an average 52 per cent.

Quartz impurities 20 to 45 per cent., with an average 35 per cent.

Fluxing impurities 8 to 20 per cent., with an average 13 per cent.

It is observed that they are lower in the scale of fusibility than the potters' clays, between which and the tile or brick clays they constitute a connecting link. The clay body for the required wares has been heretofore derived from shales or from recent deposits of alluvial pipe clays or, more ordinarily, from a mixture of the two. The shales ordinarily employed as a source of tile clay approximately conform to the limits above indicated.

The principal difficulties obstructing the use of shales alone are found in the expenditure of power necessary to reduce them to such a degree of fineness as develops the proper plasticity, where the minimum tensile strength should exceed fifty pounds; a very serious difficulty results from the small margin between the points of vitrification and viscosity, endangering over-burning to the prejudice of strength and shape. There should be a margin of 80 degrees C., or more, between these points. This, however, is rarely realized, and it becomes necessary to mix with these shales a clay of more fusible nature, such as a high grade pipe clay, so as to increase this margin. Pipe clays thus required to be mixed with shales are approximately represented within the following limits of composition:

Clay base	40 to 65 per cent.
Quartz impurities	20 to 55 per cent.
Fluxing impurities	4 to 10 per cent.

The combined tensile strength consistent with best practice should not be less than one hundred pounds to the square inch, although some clays are worked of much inferior strength.

Vitrified wares are salt glazed; the clays, therefore, should have sufficient silica to ensure uniform combination over the entire surface with the sodium of common salt.

It is to be noted that shales are accredited with much larger proportions of fluxing impurities than they respond to, in their fusion points. Iron oxide ordinarily constitutes exceeding half of these impurities, and it possibly occurs in the form of fine, hard grains of magnetite, or haematite, which are probably not readily affected by the solvent action of slightly vitrified slags. Grains of iron sulphide are objectionable by reason of the blistering action of the sulphuric anhydride and sulphurous acid formed at higher temperatures, and through the formation of blotches incident to the action of the vitreous matrix on the porous oxides at these temperatures. The sulphates of the alkaline earths are also objectionable on account of their blistering effects at high temperatures, the sulphuric anhydride becoming disassociated.

Properly vitrified wares should not absorb more than two per cent, of their weight in water after an immersion of ten hours, as otherwise they become subject to the dangers of freezing. They should furthermore be able to resist a crushing strain of not less than eight thousand pounds to the square inch, in order to insure proper toughness and strength.

PIPE, TILE AND BRICK CLAYS.

These clays cover an even wider variation in composition than in the grades and varieties of their product, affording the following approximate variations:

Clay base	20 to 65 per cent.
Quartz impurities	30 to 65 per cent.
Fluxing impurities	3 to 20 per cent.

Incipient fusion occurs at temperatures varying from 925 degrees C. or 1700 degrees F., to 1115 degrees C. or 2100 degrees F. The physical features vary as follows:

Specific gravity 2.40 to 2.60.

Air shrinkage 3 to 15 per cent.

Fire shrinkage 0 to 8 per cent.

Tensile strength 50 to 250 pounds per square inch, good practice requiring not less than 50 pounds.

These clays should have, in addition to good tensile strength, smoothness and fair plasticity. An excess of plasticity requires a greater expenditure of energy in the pugging, tempering, and molding, and sometimes causes lamination, and frequently a "ragging" of the edges upon leaving the die; it also creates a tendency to crack in both drying and burning, by reason of the irregular shrinkage and the dense obstruction to the escape of moisture and combined water. The shrinkage is in general proportional to the water eliminated, and on account of the resulting density, or nonporosity, it produces a cracking or warping of the ware at the point of vitrification, by the irregular diffusion of heat through the mass. In the absence of proper porosity the gases fail to penetrate the body of the brick, causing a difference of color from the surface to the center, by reason of the incomplete oxydation of the iron, except at the surface, where it will be red—the interior being of a brown black color characteristic of the iron compounds in a lower state of oxydation. The difference in the degree of oxydation of the iron compounds also causes a difference in their respective points of fusion, with the result that the exterior may be partly and the interior fully vitrified; or conversely, with corresponding irregularities in contraction.

The amount of water required to develop the full plasticity of a clay is in a measure proportional to that plasticity, and, as the evils incident to the drying and to the shrinkage are largely determined by the presence of this water, clays of high plasticity are frequently molded by the semi-wet or by the dry process, whereby the amount of water is accordingly reduced. Salt water is occasionally added to prevent rapid drying by reason of the hygroscopic nature of salt, causing it reluctantly to relinquish water.

The presence of sand decreases the tensile strength and diminishes the plasticity, and therefore economizes the energy required in tempering and molding. The tendency of sand grains to expand under heat reduces the shrinkage and increases the porosity, but in excess produces a weak crumbling ware.

The evils of excessive plasticity may therefore be reduced by the judicious addition of sand or by the admixture of more arenaceous clays, but both of these methods are prejudicial to such smoothness as is required of face brick. In some sections, where coal is cheap, this article is ground and then mixed with the clay in the pug mill; it reduces plasticity, and facilitates escape of moisture in drying and burning, and as it is consumed as the temperature advances, it leaves the brick slightly porous and therefore more uniformly responsive to the action of increased temperature, thereby obviating cracking, twisting and warping. Furthermore, its combustion supplies a portion of the necessary heat. Many of our recent alluvial or sedimentary clays contain sufficient organic matter to dispense with the addition of these correctives for the evils in burning, for it acts in a manner similar to coal. But it is in such soft particles that it absorbs water and adds to the plasticity with the attendant evils in drying. Some of our alluvial clays contain as much as four per cent. of organic matter.

These clays upon burning should afford an attractive red color, which depends upon the presence of iron oxide, the best color obtained under average conditions being afforded by approximately six per cent. of this oxide. The condition of the furnace flame, determines the shade imparted by the iron oxide. The presence of lime tends to mask in a measure the color of the iron, and to correct the shrinkage tendency, in some cases causing the brick to slightly expand beyond its original dimensions. Many of the cream colored bricks are made from such calcareous clays.

Brick clays occur extensively in South Carolina over the crystalline area as residual, meta-residual and sedimentary deposits. They are distributed over the Coastal Plain as sedimentary beds, and in the case of the lixiviation of argillaceous marls they occur as residual deposits.

Throughout the Piedmont Region the lower grades of clay are found residual to the extent that the altered gneisses, feldspathic schists, etc., have escaped degradation. This degradation, or erosion, has contributed to the formation of higher grade, sedimentary, potters' and pipe clays occurring in the valleys of the crystalline region, and over the area of the Coastal Plain formation. As a general proposition, it may be said that the nearer a sedimentary deposit is located to its parent residual bed the more closely will it conform to the type of its progenitor, frequently including its softer and finer impurities, as well as the clay substance in a concentrated

form, the coarser particles having been eliminated in transit; however, in some belts characteristically feldspathic, excellent residual beds are afforded. But, on the whole, the sedimentary valley beds of the crystalline formation are the most important sources of supply of these clays in this State. Characteristic of these latter supplies, we find prominent deposits at North Augusta, Brookland, Columbia, Camden, and Society Hill. Above this fall line they occur more or less through the much ramified tributary valleys. Below the fall line the Cretaceous and Eocene formations afford occasional beds answering the requirements of these clays, but in the Coastal Plain area it is not until we approach what probably represents the upper member of the Neocene formation that we find clays conspicuously valuable as brick clays. Such deposits extend from Garnett, on the Savannah River by Walterboro, Summerville, St. Stephens, Marion, and thence to the North Carolina line, the entire distance affording an undulating zone of detached areas of good clay, some being adapted to the manufacture of high grade face brick.

FULLER'S EARTH OR WALKER'S EARTH.

This earth derives its name from its former use in the extraction of grease.

In England these beds form a distinct subdivision of the Triassic formation, but in South Carolina the so-called Fuller's Earths are clays belonging to the Eocene and Neocene formations, and are of approximately the same composition except in the water content, which is much lower.

A classic English analysis shows:

Silica	53.00 per cent.
Alumina	10.00 per cent.
Ferric Oxide	9.75 per cent.
Magnesia	1.25 per cent.
Lime	0.50 per cent.
Sodium Chloride	0.10 per cent.
Water	24.95 per cent.

However, many slight departures from this composition, and an occasional association of the alkalies, give name to several varieties.

Fuller's Earth is now extensively employed in the bleaching of mineral, animal and vegetable oils and fats. The alleged chemical bleaching in the process is highly questionable; its action more properly involves the mechanical entanglement of the suspended coloring matter by the contained clay substance.

Fuller's Earth in South Carolina is found in white, gray, yellow, pink and black colors. It varies in specific gravity from 1.75 to 2.00, the lower limit being determined by included air spaces. The best varieties crumble in water accompanied by a faint sizzing sound. The Eocene Fuller's Earth, when dry, adheres to the tongue; it extends in a broken sinuous band across almost the entire State, with its upper margin varying from 10 to 20 miles southerly from the "fall line." In some localities it approximates forty feet in thickness, and occasionally affords fossils of Eocene fauna and flora. The presence of marine shells, however, is a bad augury for its serviceability, for implied salt water antecedents of the greater part of the bed of Eocene Fuller's Earth is frequently strengthened by the presence of sulphates in the form of alum, probably derived from the alteration of pyrites, which was previously formed by the action of organic matter on the salts of brackish water, in the presence of iron compounds. The presence of alum is most prejudicial to the value of Fuller's Earth employed for the treatment of the culinary or table oils and fats. The Eocene Fuller's Earth of the extreme upper portion of the Coastal Region, where the antecedent conditions were characterized by fresh water, is generally free from sulphates in objectionable forms and quantities.

The beds of Neocene Fuller's Earth are in detached patches dotted over the median and submedian portions of the Coastal Plain. As compared with the Eocene Fuller's Earths they afford superior satisfaction.

Fuller's Earth is utilized in the following manner: After having been partly air dried it is burned at a low red heat on open iron plates of semi-cylindrical shape, constituting the top of a long furnace. It is gradually charged upon the end adjoining the stack, and slowly raked to the opposite end, where it is discharged, cooled, and then ground to pass a ninety mesh screen. It may be burned in rotary cylindrical dryers, provided the products of combustion are confined to the outside of the cylinder, especially where coal is used as the fuel. The products of combustion prejudice both the odor and the taste of Fuller's Earth. This burning serves to eliminate the water, to destroy organic matter with its prejudice to odor and taste, and to render the earth more porous and therefore more adhesive to the suspended impurities of the oils, etc.

The grinding is ordinarily done in buhr-stone mills the product of which is "railed," or otherwise screened, to insure the required fineness. However, any type of good iron roller mill satisfactorily performs the work. Some manufacturers employ the horizontal revolving cylinder with gravity balls.

In the case of cotton seed oil this pulverized earth, in proportions varying according to the grade of the earth from 5 to 7 per cent., is added to the crude oil, in a large vertical iron cylinder equipped with a peripheral steam coil and a central revolving agitator, which are employed, respectively to heat the oil to 180 degrees F. and to stir the mass so as to bring particles of the earth in contact with all particles of suspended coloring matter. The mixture is then pumped under pressure into the filter press, causing at the same time the suspended Fuller's Earth to deposit on the inner surface of the canvas filter, and the oil to filter through this coating of the earth and the canvas; the aluminous Fuller's Earth mechanically entangles all suspended matter. The filtrate should be clear, colorless and without objectionable taste or odor; while an increase of the contained aluminous substance increases the bleaching effect it decreases the filtering quality. We may therefore, as a result of practical experience, prescribe the following essential attributes of a Fuller's Earth acceptable to the trade:

a. It must be finely subdivided, and free from such abrasive matter as might increase the wear of the pump cylinders, pistons and valves.

b. It must contain as much bleaching substance as is consistent with rapid filtration under a pressure of sixty pounds, for the reason that its value is proportioned to the amount of bleaching power exercised consistently with the other requirements.

c. It is observed that where the alumina exceeds one-fifth of the amount of the silica present, the critical point is approximated, beyond which an increase in the densely bedding aluminous matter prejudices filtration. The silica therefore serves to maintain the required porosity.

d. In the bleaching of cottonseed oils, lards and other organic oils, or fats, required for culinary purposes, the presence of matter affording foreign flavors or odors constitutes a fatal objection. In the treatment of the mineral oils and of those organic oils used for illumination, fuel, lubrication, etc., the same fastidiousness is not essential.

CHAPTER VII

THE MINING OF CLAYS.

RESIDUAL KAOLINS.

The mining of the residual deposits ordinarily involves no features more difficult than the driving of an open cut as wide as the vein of the decomposed feldspathic substance, after first stripping the surface free from drift matter. The ore is either removed on tram cars or hoisted on swinging booms. The drainage features are quite simple, being effected either by steam pumps or by gravity, according to the character of the development.

The ore thus mined affords ordinarily about twenty-five per cent. of kaolin, which is concentrated by the usual washing process, hereinafter described as applying to both the residual and some sedimentary deposits.

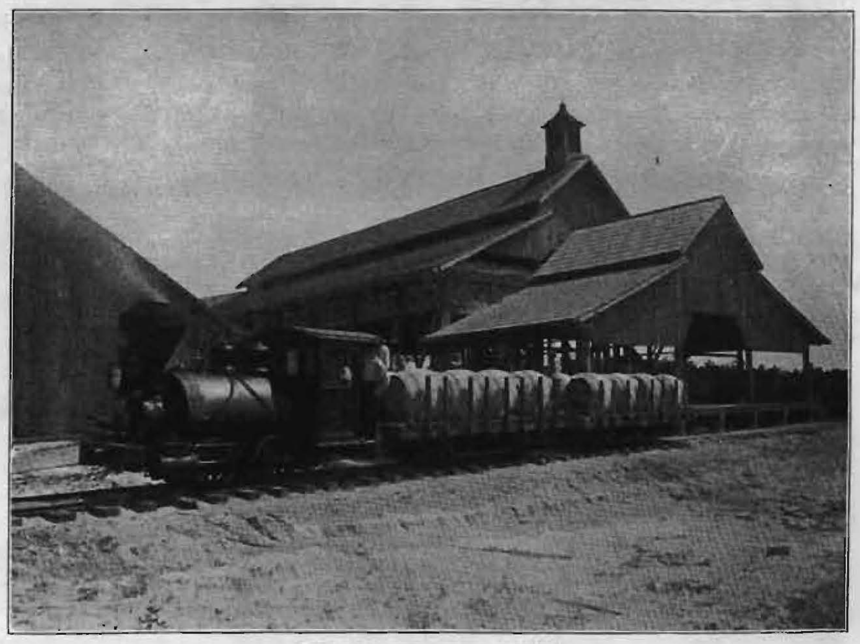
The ore from these residual deposits is sometimes mined hydraulically by tearing down the mass with streams of high pressure water, which with the kaolin in suspension is pumped to the settling troughs of the washing plant, where it undergoes the usual treatment.

SEDIMENTARY DEPOSITS.

The mining of a sedimentary deposit of clay as it occurs in the crystalline formation resolves itself into a simple pick and shovel process, with due regard for good simple drainage either by gravity or by steam pump.

In mining the heavily bedded sedimentary beds of kaolin of the Coastal Plain area several systems obtain. As typical of usual practice the process ordinarily employed in connection with the Aiken beds of the Savannah system is described. The overburden, which consists usually of massive, stratified or cross-bedded sands with a seam of coarse white, sub-angular, water-bearing sand immediately superimposed on the kaolin, aggregates from five to fifty feet in thickness. The thickness of the bed of marketable clay determines the limit of admissible overburden consistent with economic considerations. The underlying kaolin usually occurs in stratified deposits attaining as much as eighteen feet in thickness. The upper portion, when soft through contamination with more or less mica and fine sand, is known to the miners as "ruggage," which is waste.

SEDIMENTARY KAOLIN MINE—REMOVING THE OVERBURDEN.



SHIPPING CASKS OF KAOLIN.

This is frequently missing and rarely exceeds two feet in thickness. This upper portion in Aiken County is sometimes replaced by unconformable, more or less indurated clays, sometimes by purple clays, sometimes by clays in thin layers interlaminated with particolored sands. The upper portion of the compact kaolin is in some instances slightly tinted, especially where the overburden which affords a filter to percolating water is thin or of a highly ferruginous character. The lower portion, often twelve feet in thickness, is very white and compact, and free from grit or other foreign matter in discernible quantities. Below this portion the kaolin usually graduates into, or abruptly terminates on, a bed of very pure white sand, well suited to the requirements of the glassmaker.

Kaolin mines appear either as large pits which are drained by steam pumps, or as open cuts with gravity drainage; in both cases they are developed along vertical breasts which are advanced in line as the mining progresses. The overburden breast, which is kept well in advance of the clay breast, is degraded by a system of manual undermining or by steam shovels, and removed to the rear. The clay breast, which thus constitutes a terrace, is mined with picks and shovels and removed to the dry shed. As the clay is thus mined men provided with hand scrapes remove any conspicuous surface stains, break the large lumps to sizes less than a half cubic foot, and roughly assort the grades as determined by color. An incline over which the clay is removed usually extends from the bottom of the pit or cut to the upper portion of the dry shed, which it enters under the line of its peak, and tram cars or carts distribute the clay into the bins or racks lying below, on either hand, in superimposed series. These racks are usually four feet deep by fourteen feet wide, and extend the length of the shed. Their bottoms are formed of movable 3x4 scantlings loosely spaced. A dry shed of ordinary size will thus accommodate a thousand tons of clay, which requires for its air drying and slight bleaching a period of time, varying with the atmospheric conditions, from three to six weeks. The number of tiers varies from three to six. As the contents of the lowest tier become dry they are dropped on the floor, and those of each superimposed tier are dropped upon the one next below, by shifting its loose bottom. The dried kaolin dumped on the floor is broken with mauls, or in crushers, to sizes admitting of easy packing in casks of a capacity of about 2,200 pounds, the kaolin and the casks weighing 2,300 pounds, which constitutes the freight ton basis of clay rates. In some instances the kaolin is disentegrated in machines and shipped in sacks of close texture.

This kaolin is ordinarily graded No. 1 and No. 2, the distinction being one of slight variation in color.

The cost of the casks is about one dollar each, and the cost of filling, packing, and coopering the top averages twenty-five cents. Kaolin No. 1 is now marketed at or about $8.00 per ton, delivered at New York, and the grade No. 2, at or about $7.00 per ton.

In some sections of Florida, where the Coastal Plain clays are contaminated with foreign matter in amounts as high as 75 per cent., a system of mining prevails which is noted with a view to its application to some of the South Carolina deposits.

The overburden is removed along similar lines to the ones already indicated. A basin is dug in the bed of clay and filled with water. A covered lighter equipped with boiler, engine and a rotary pump of large capacity is floated in this basin. A vertically installed auger about fifteen inches in diameter, extending to an adjustable distance below the flat, is rapidly revolved by a suitable mechanism so as to loosen and stir the underlying clay mass. The induction end of the flexible suction pipe of the rotary pump is supported close to the field of action of the auger, where it sucks in the water with suspended clay, sand, etc., which is forced through another flexible pipe, supported on pontoons, to a rigid pipe on shore, which discharges into the troughs of the washing plant through coarse screens. The flexible delivery pipe enables the lighter to be gradually shifted from one side of the pit to the other, and to be advanced by inserting additional sections of the delivery pipe. This system requires a continuous source of supply to repair the loss in the amount of the discharged water, which is eventually returned to the pit to resume its service cycle. There are several low grade beds of sedimentary kaolin in South Carolina which could be utilized through this process. One is now being worked by the manual process already described, the mined product being then removed to the blunger of the washing plant to be freed from its impurities.

METHOD OF WASHING CLAYS.

The washing of clays is undertaken to remove their associate impurities. The fundamental principle of the process rests upon the superior transportive susceptibility of the kaolin, by reason of its greater fineness of particle and its lesser specific gravity as related to the greater part of its associate minerals.

PLATE III.

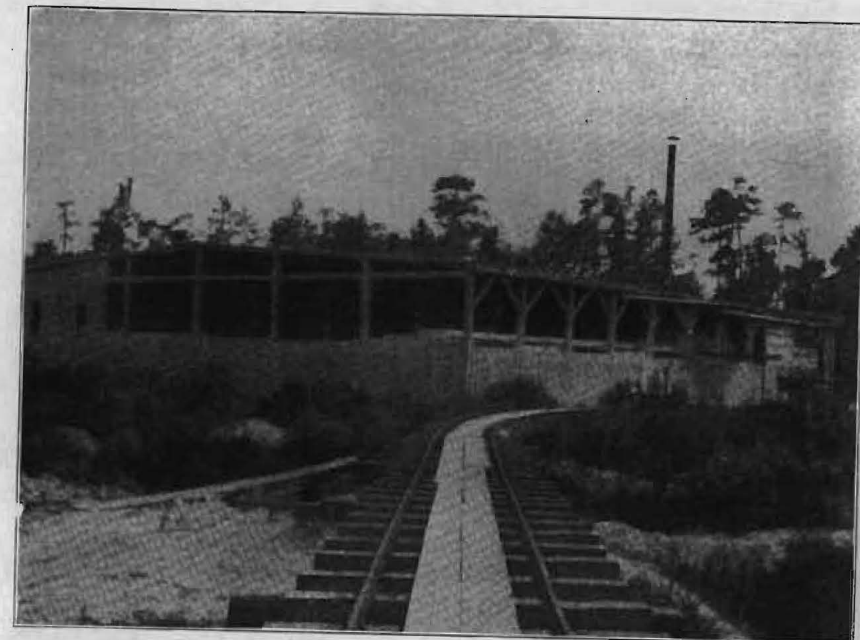
CONVEYING KAOLIN TO THE "DRY SHED."

The clay is first charged into a blunger (with a "U" cross-section) about ten feet long and four feet wide, where a concentrically located horizontal shaft equipped with heavy arms, and revolving in water, reduces the clay mass to a pulp. This action is expedited by the admission of live steam. The coarser particles settle to the bottom to be removed by hand or by sand wheels. A continuous flow of water directed through the blunger conveys the suspended particles to a battery of troughs aggregating from six hundred to eight hundred lineal feet, which are arranged in successive terraces in sections ordinarily varying from fifty to eighty feet in length. The troughs are given a pitch of about 0.04 per cent., varying with the average character of the material to be handled; in some instances the upper sections are given a pitch slightly greater than the lower sections. Each of these sections of trough at its initial end should be about eighteen inches wide and at its terminal end about twenty-eight inches wide, the sides being sloped about eight inches in a depth of fifteen inches. The terminal end of each trough is connected by an eight-inch trough with the initial end of the succeeding trough. The progressive increase in the cross-section of each trough serves to successively decrease the velocity of the flow, or affords pulsations with corresponding precipitations of the coarser suspended particles. The slip from the lowermost trough is delivered on an oscillating screen of one hundred mesh fineness, or into a corresponding rail, which removes coarse light particles, such as vegetable matter, mica, etc., the screened slip being delivered into the settling tanks. Upon filling one tank the flow is shifted to a second, and so on. The use of alum to facilitate this settling is occasionally adopted. At this point the process varies according to whether filter presses are to be employed, or whether the clay is to be dried in the tanks through the use of steam coils after decanting the clear supernatant water through bung holes located for this purpose.

The latter system requires a large multiplication of the number of tanks, and involves a smaller outlay, but is tedious in operation. In the filter press process the mass is stirred by suitable agitators, to insure a uniform consistency of the slip as delivered from the tanks through the pump to the filter press under a pressure of about 125 pounds to the square inch. This system is much more expeditious, but involves an increased outlay for the pump and filter presses, which should not, however, exceed a cost of $2,000.00, for the fifteen ton plant, assuming that the required boiler and engine power are already available. The hydraulic pressure can be advantageously substituted with pneumatic pressure, the slip being first admitted to an egg or drum about 3½ feet in diameter by 10 feet long. The compressed air could probably be best admitted through a perforated pipe extending inside of the drum along its bottom, as this would serve through agitation to keep the pulp in a uniform state of consistency. The air following the final traces of water through the pores of the clay-cake expedites the drying. The leaves or cakes of kaolin deposited on the canvas filters, weighing about forty-five pounds each, are folded and placed in drying racks in steam heated rooms, and thence taken to the packing room to be shipped in sacks.

Washed clay is essentially finer and smoother, and freer from soluble matter than the natural clay. The increased compactness, however, predisposes checking in the furnace.

PLATE IV.



CLAY WASHING PLANT—EDISTO AREA.

INTERIOR OF CLAY WASHING PLANT—EDISTO AREA.

CHAPTER VIII.

GEOLOGICAL OCCURRENCE AND AREAL DISTRIBUTION OF THE SOUTH CAROLINA COASTAL PLAIN CLAYS.

AIKEN OR SAVANNAH RIVER AREA. EDISTO AREA. SANTEE AREA. PEE DEE AREA.

The formations and materials constituting these areas occur in the following order of superposition:

Recent.—Thin beds of sands and clays in sections subject to recent inundation. Economic products: Structural sands and some brick clays.

Post Pliocene.—Beds of sands, loams, clays and shells. Economic products: Brick clays.

Neocene.—Eolean sands, Lafayette clays, loams, sands, cement gravel and cobbles. Prominently developed across the upper part of the coastal plain. Economic products: Sand supply for locomotives, molding sand: cobblestones and cement gravel for road construction and railway ballast.

Pliocene, Miocene and Oligocene (?) marls, clays and sands. Economic products: Fuller's earth, brick clays, sewer pipe and tile clay; phosphate rock; marls adapted to the manufacture of cement and lime; marl and greensand for agricultural purposes.

Eocene.—Dark laminated clays, sands, ferruginous sandstone, Eocene grit, buhr-rock; fine grained yellow Sienna and purple sands and loams; shells, greensand, marl, siliceous clay enclosing layer of buhr-rock, coarse fossiliferous sands, sandy loams, lignitic clay. Occupy approximately the median two-fourths of the coastal plain, irregularly parallel to the fall line. Economic products: Fuller's earth; potter's clay; structural and mill stones; lime marl; greensand and marl for agricultural purposes.

Cretaceous.—Buff colored high grade marl; greensand marl; clay marl; black clay. Economic products: Lime marls; agricultural marls; clay marls suited to the manufacture of vitrified brick.

KAOLIN BED WITH TWO SUPERIMPOSED UNCONFORMABLE FORMATIONS.

Middendorf—white sands, (25 ft.), bed of dense white and drab kaolin with waxy luster (fossiliferous); harsh sands; vari-colored cross bedded fine grained sands; thin seams of colored clay interlaminated with sands; gravel. Economic products: China clays; paper stock clays; "glass sand."

Hamburg—From nil to eighteen feet of fine white kaolin, white sands in micaceous kaolinitic matrix; vari-colored banded sands; arkose; purple and white kaolin; arkose; sub-angular bowlders and fragments of quartz, slate and gneiss in arkose matrix.* Economic products: China clays, paper stock clays, potter's clay, "glass sand."

The Cretaceous occupies the upper fourth of the coastal plain of the Aiken, Edisto and Santee Areas and both the upper and lower fourths of the Pee Dee Area.

Crystalline.—Shales, schists, granulytes and gneiss with their upper portions kaolinized. Economic products: Residual clays; meta-residual clays; inferior cornish stone and feldspar; superior structural stones.

The province of this report comprehends such of these materials as are adapted to the Ceramic arts.

THE AIKEN OR SAVANNAH RIVER AREA.

The Aiken Area affords one of the most remarkable exposures of clay in the United States, not only in its relations to quality and to quantity, but in the scientific interest attaching to it and to the instructive phases of the associate crystalline rocks.

GEOGRAPHIC LIMITS.

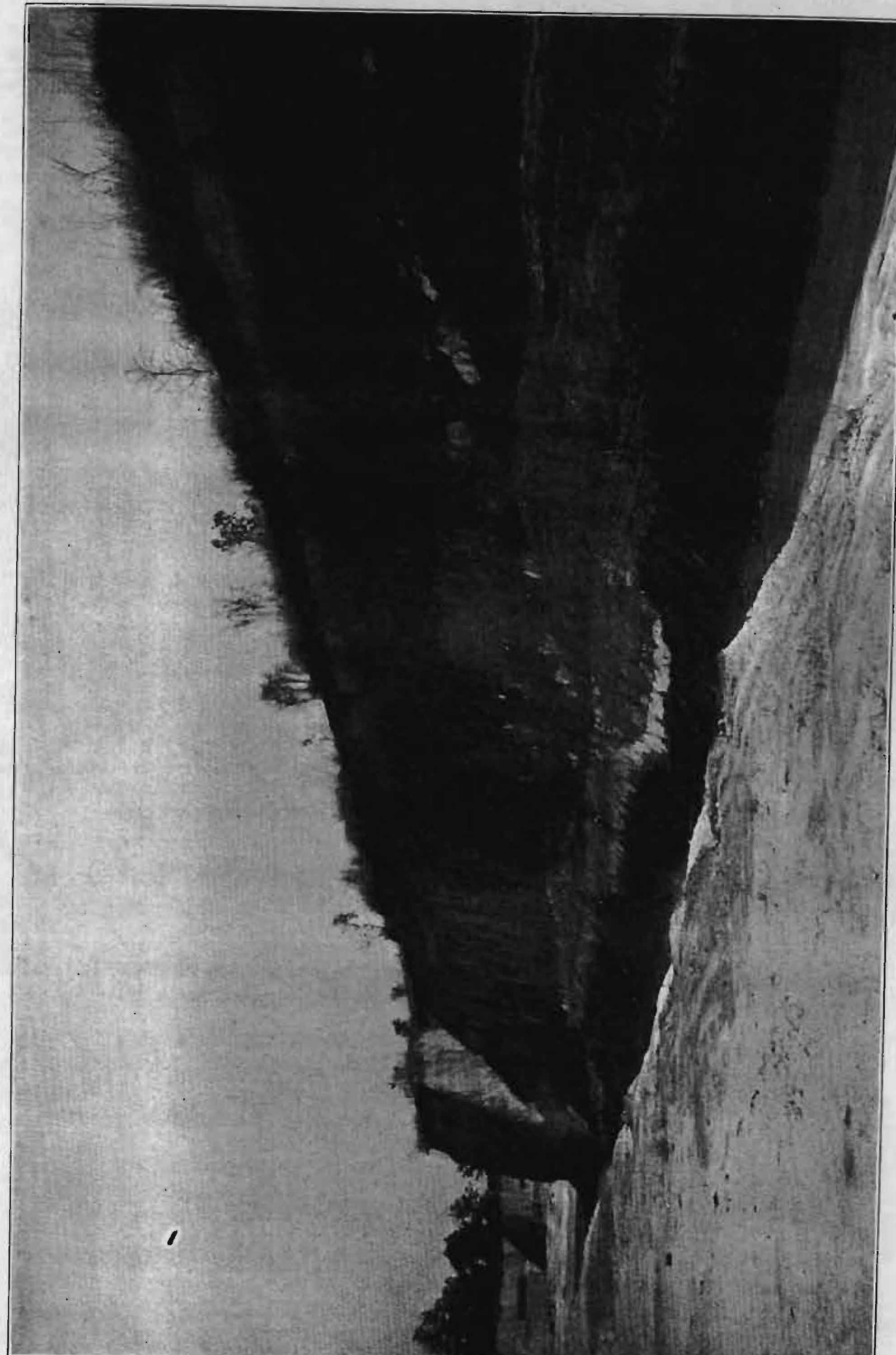
This terrane is bounded on the west by the Savannah River, on the north by a line from the mouth of Foxes Creek to Trenton, and on the east by the watershed dividing the drainage of the Edisto and Savannah Rivers, which extends along the Edgefield and Aiken highway to Aiken, and thence by Windsor and Coosawhatchie to the ocean.

PHYSIOGRAPHIC FEATURES.

This area constitutes a Cretaceous and Tertiary peneplain with the upper plateaus at an elevation of 527 feet above the sea but

*Beds of lignic clay and arkose revealed by borings below the valley lines probably are the equivalents of the Potomac or basal member of the Cretaceous.

PLATE V.



KAOLIN BED WITH TWO SUPERIMPOSED UNCOMFORMABLE FORMATIONS.

gradually declining southerly to the Atlantic Ocean. At the mouth of Horse Creek the low water level of the Savannah River is 113 feet. Hollow Creek drains southwesterly the sub-median part of the Aiken County portion of this area; it does not descend to the Crystalline rocks; its exposures are predominantly Tertiary, a little of the underlying Cretaceous appearing near its heads. The exposures of the "Three Runs" drainage systems which lead through Barnwell County are essentially Tertiary, under which the Cretaceous formations decline southerly.

Horse Creek, with its tributaries, Little Horse Creek, Kine's Fork, Bridge Creek and Wise Creek, from the north and east, constitute the principle drainage system of Aiken County. Its valleys have been eroded 200 feet in depth through the sedimentary beds, and with the exception of Wise Creek and Bridge Creek Valleys, now find channels on the Crystalline rocks. This section affords not only the most prominent Cretaceous kaolins in South Carolina, but vast deposits of meta-residual clays and some of residual character.

The Horse Creek system, with its pre-Cretaceous drainage area on the decomposed gneisses and on the meta-residual beds, doubtless contributed much of the pure kaolinitic material of the Aiken Area, free from the iron discolorations characteristic of the sediments of waters proceeding from the hydro-mica-schist region. At some points grit was probably introduced by the local drainage from the sand islands and the mainland during storm periods.

At Aiken, from an elevation of 527 feet above the sea level, artesian wells encountered granite at a depth of 490 feet, or 37 feet above the present sea level. A line projected from this cluster of wells normal to the trend of the Crystalline Region, intersects the line of gneisses above Vaucluse at an elevation of 307 feet and at a distance of five miles, thereby representing a decline of 54 feet to the mile for the bed of the Cretaceous.

An inspection of the physiographic and structural features of this terrane, which comprised the coast of the Cretaceous waters, affords interesting suggestions as to the conditions which in part determined the irregular distribution of the sediments constituting this formation.

The Cretaceous current line of the Savannah River, as inferred from the deep incisions of its valley in the Crystalline rocks where it debouched into the ocean, was southeast. A part of its waters gave impetus to an easterly current sweeping parallel to the Crystalline shore on which it deposited Cretaceous sands and other materials, and at the same time formed offshore a more or less broken area of extensive sand flats protected from the ocean by sand ridges, which diverged from the mouth of the Savannah River, and continued to raise their surface as the land subsided.

These vast reef-locked and undulating flats represent the areas on which the clay sediments accumulated as fine-grained pure kaolin where the waters became still—notably in the sand atolls—but as gritty coarse-grained clays and arkose interstratified with sands along the current lines. With a renewed depression of the coast, or an increased height of the waters, the surface of this area became partly eroded by new currents which deposited successively gravels, coarse sands and fine micaceous sands until protection by the increased height of the reefs produced again a period of calm waters, when an additional deposition of clay ensued. During the phases of the increased flow of the waters from the land the fine clay materials were principally borne to the ocean to be deposited in its still areas and enter the formation of clay marls. One of this sequence of cycles is partly illustrated in the deposit of marsh mud on the flats within the sand islands of our present coast. The principles above indicated appear abundantly attested in the Aiken Area.

CRYSTALLINE ROCKS.

The crystalline rocks of the Horse Creek section comprise gneiss, quartize, granulyte, schists and shales, which strike about N. 59 E. and dip N. W. 80 degrees with the horizon.

The shales exhibit broad-banded zones of plastic material, the ochreous and gray white colors of which alternate in almost sharp precision. They represent either strata of decomposed feldspathic shales or highly titled beds of slightly indurated clays including veins of quartz, and in some localities potstone partings. The amount of plasticity varies with the degree of exposure, and "in feel" this shale is highly unctuous and suggestive of magnesian influences. The inference is not sustained by analyses, which reveals only a trace of magnesia. The shales are exposed at Hamburg and along all of the enumerated tributaries of Horse Creek, except Bridge Creek and Wise Creek. In addition to natural exposures, certain drainage excavations opposite the North Augusta Bridge exhibit interesting sections of the same deposit. Near the old Landrum pottery extensive beds of decomposed granulytes and shales afforded prominent sources of clay. The granites and gneisses lying to the south of

these meta-residual beds are prominently exposed in Horse Creek Valley, from a point one and a half miles above Vaucluse to Graniteville. Near Vaucluse, in the bed of the stream, the rock occures in its pristine hardness, whereas in the recent railway cuts the gneiss is exposed weathered in great concentrically lined masses, closely approximating Cornish stone in composition. Thus we have beds of residual clay underlying the Coastal formations, which in this vicinity are on every hand superimposed in beds exceeding 200 feet thick. Mr. Tuomey's report, wherein he recites that no decomposed feldspathic products exist in situ in this valley, was made long in advance of the excavations which favored my examination of the region.

The relations of the successive elements constituting the Aiken beds are exhibited in the following consolidated section:

Consolidated Section of the Aiken Beds. Surface Elevation 440 Feet.

		Feet.	Feet.	
PLIOCENE(?)	X	40	8	Eolean Sands.
			2	Lafayette Cobbles.
			10	Lafayette Loams.
			6	Lafayette Mottled Clay.
			13	Coarse Sands.
			1	Pebbles.
				Unconformity.
MIDDENDORF.	F	54	18	Pale greenish yellow and white fine grained hard clay, very unctuous.
			12	Micaceous Sands.
			15	Pale greenish yellow and white fine grained hard clay, very unctuous.
			9	Mixed Sands.
				Kaolin nodules.
				Plain of Erosion.
	E	30	30	Cross-bedded, white, pink, purple and orange friable sands.
				Plain of Erosion.
	D	9	7	Thin layers of clay interlaminated with sands.
			2	Rounded Quartz pebbles, 3 inches in diameter in sand matrix.
				Unconformity.
UPPER HAMBURG.	C	71	14	Fine white plastic Kaolin, 39 per cent. Alumina.
			9	Intimately mixed white Sands and Kaolin.
			28	White and yellow Sands with Kaolin balls and lenticles.
				Kaolin nodules.
				Plain of Erosion.
LOWER HAMBURG.		51	51	Mealy micaceous Sands.
				White and colored sands with streaks of Kaolin.
				Harsh sands.
	B	59	19	Harsh white arkose.
			11	Purple Clay.
			25	Coarse white and yellow sands.
			4	Sub-angular fragments of quartz and gneiss in coarse clay matrix.
				Unconformity.
	A			Shales, gneiss, etc.

Along the more southerly exposures the characteristic Eocene beds intervene between the horizons of F and X in the above table.

HAMBURG BEDS.

Unconformably superimposed on the crystalline rocks at Hamburg (C. No. 2*), and along the median portions of Clear Water Creek (C. No. 12*) and Little Horse Creek (C. No. 17*), and along Big Horse Creek from Miles Mill to Graniteville, are found sub-angular granitic and quartzose fragments (some as large as two feet through) embedded in a sandy clay matrix, the whole varying in thickness from nil to four feet. Succeeding this formation coarse white and yellow sands enclose in some localities pockets and lenticles of white clay. Overlying these sands a bed of clay occurs, varying in thickness from nil to eleven feet; it is in some places fine grained and very purple with organic stains, and sometimes white in part; in other places it appears very gritty and more or less indurated. The plane of this clay bed declines in approximate conformity with the surface of the underlying crystalline rocks, which its upper edge approaches along an irregular and broken line about five miles from the fall line and at an average elevation of 285 feet above the sea level. Its dip carries it below the valleys south of the main Horse Creek Valley. East of Langley it appears to have feathered out on a Hamburg sand ridge, which extended under the site now occupied by Aiken. A bed of coarse sands rests on the surface of this clay.

The succeeding elements of the Hamburg phase are indicated in the consolidated section and engage no special interest until we ascend to the upper Hamburg kaolin, except in the fact that the sands of the lower Hamburg accumulated along the mainland and reefs to a greater height than the enclosed flats on which the upper Hamburg kaolin was deposited.

The most prominent exposures of the upper Hamburg kaolin bed now appear near the top of the plateau southeast of Horse Creek and opposite Bath and Langley. The surface on which it was deposited constituted a Cretaceous flat, limited on the north by a contour line on the escarpment of lower Hamburg sands at a maximum elevation of 371 feet (M. L. T.). At this level the upper Hamburg clay feathers out in tongues and thin broken layers along the hills and valleys northwest of Horse Creek up to its confluence with Wise Creek, from which point it proceeds in an arm extending under

*Survey number of geological exposure.

the southerly escarpment of Cemetery Hill, again makes a limited appearance on the northern slope of this hill and probably constitutes the lower part of the bed at China Springs (C. No. 195), the Middendorf being in contact above. A meridian line through this point constitutes the easterly limit of any observed exposures of the upper Hamburg kaolin in the Aiken area, a suggestion sustained by borings at Aiken, where neither of the Hamburg clay beds is revealed. From the littoral line of the upper Hamburg, as above outlined, the plain of this kaolin bed declines southerly. On the south side of Horse Creek Valley, as exposed on the places of the Paragon Kaolin Works (C. No. 110), and of the T. G. Lamar Kaolin Co. (C. No. 105), and at the McNamee Mines (C. No. 100), the elevation of the upper surface of clay is 307 feet; in a more southerly valley its micaceous equivalent is at an elevation of 264 feet (C. No. 114); along a small branch one mile north of Sand Bar Ferry its apparent equivalent is at an elevation of 168 feet (C. No. 120). A line projected from Sand Bar Ferry N. 34 E. for 5.5 miles is the approximate upper margin of the Middendorf clay beds, under which the Hamburg declines.

The upper Hamburg kaolin occurs in beds varying from nil to eighteen feet in thickness.

The surface of the upper Hamburg kaolin bed is extensively eroded and affords pronounced false unconformity to the overlying materials, which I have designated Middendorf by reason of their characteristic exposure with fossil leaves near that point.

The sands of the Middendorf phase and of the Lafayette constitute in the main the overburden of the upper Hamburg kaolin. The amount of overburden in some parts of this area prohibits economic mining of the kaolin; at certain points on the main plateau under which the Hamburg kaolin level is estimated at an elevation of 307 feet M. L. T., the Lafayette cobbles on the surface of the plateau are at an elevation of 490 feet M. L. T.

Taking as typical of the upper Hamburg kaolin the product of the very thick exposures developed along Horse Creek Valley, this kaolin is in the main very white, highly plastic, fine grained and free from grit, but is low in tensile strength, 16 pounds per square inch approximately represents the maximum. It requires no other preparation than drying. In some parts of this bed an organic purple color prevails, but is eliminated by the bleaching effects of light and air; in other parts a slight iron stain from infiltration in the upper part creates a second grade of clay designated Clay No. 2.

The density of this clay varies from 2,300 to 2,400 pounds to the cubic yard on the dry basis, according in a measure to the amount of overburden. The following is an analysis characteristic of this clay:

Silica	45.02
Alumina	38.98
Ferric Oxide	0.77
Titanic Oxide	0.85
Lime	0.03
Magnesia	0.07
Soda	0.55
Potash	0.26
Ignition	13.58
Total	100.11

Rational Analysis:

Clay Substance	96.95
Soluble Silica	0.00
Quartz	2.00
Feldspar	1.16
Total	100.11

THE MIDDENDORF BEDS.

As indicated in the consolidated section of the Aiken beds, the upper Hamburg clay bed was greatly eroded (and in many instances entirely obliterated) by a southerly current upon the conclusion of the Hamburg beds.

Resting on the irregular surface thus formed, we find a layer, sometimes attaining the thickness of two feet, of rounded pebbles in a sandy matrix, overlying which in a few places a series of thin layers of clay interlaminated with sands afford a thickness of seven feet; the latter was greatly eroded and in the main obliterated before the deposit of white and pale colored sands succeeded (see plate V). Ascending over these various sands, we arrive at the horizon of the Middendorf clays, the upper surface of which along Horse Creek Valley approximates 400 feet in elevation (M. L. T.). Whereas this clay is represented in the consolidated section divided by twelve feet of micaceous sands, it frequently occurs united for a depth of twenty-five feet. I have tentatively admitted this bed to the Cretaceous, although it was for the strong reason afforded by the frequent association of the Eocene grit with this clay that Mr. Tuomey predicated the assignment of the bed and the underlying Hamburg beds to the Eocene. In fact, the Eocene formation in many parts of South Carolina exhibits no apparent unconformity with the underlying Cretaceous except in its littoral manifestations.

In its physical aspects the Middendorf clay bears a closer resemblance to certain clays of recognized Eocene antecedents than it does to the Hamburg clays. It is dense, has a sub-waxen lustre, and in color is occasionally white, but predominantly pale drab and often an almost invisible yellow green; these colors generally bleaching to a pure white on exposure to the air and light. Chemically it is almost similar to the Hamburg clays, not only in its superior content of alumina, but in the insoluble character of all of its silica. All Eocene clays whose analyses have been executed along this line in South Carolina show a portion of the silica as soluble, in some instances as much as nineteen per cent.

The following are characteristic analyses of the Middendorf clays exposed in the Aiken Area:

Silica	44.66	47.49
Alumina	37.90	35.56
Ferric Oxide	2.53	2.47
Titanic Oxide	1.29	.94
Lime	.08	Trace.
Magnesia	Trace.	Trace.
Soda	.41	.74
Potash	.36	.13
Ignition	13.17	12.86
Totals	100.40	100.19

Rational Analyses:

Clay Substance	99.60	96.43
Soluble Silica	0.00	0.00
Quartz	.16	2.27
Feldspar	.64	1.49
Totals	100.40	100.19

The biotic criteria afforded by the Middendorf clays in the Aiken Area comprise the leaves of the alder, the bay, the willow, the elm,

PLATE VI.

TWO CLAY HORIZONS—AIKEN AREA.

SEDIMENTARY KAOLIN DEPOSIT—BEAVER POND, AIKEN AREA.

the pine and a variety of cane. (In the Middendorf clays of the Pee Dee Area are found in addition to some of these species, the leaves of a variety of cypress.) With respect to stratigraphic features the Middendorf formation is greatly eroded where it passes under strata recognized as of Eocene equivalence. Along the entire extent of the Middendorf terrane in South Carolina the clay and sand beds indicate abrupt fluctuations in the original character of the currents which formed these deposits. The surface on which the clay was deposited was highly irregular, determining the clay forms as inclined and level lenticular masses, some of great extent. The edges are often inclined at various angles, both up and down, and extend above and below the limiting planes of the body of the clay deposit. This clay bed is often observed dividing to accommodate huge sand horses (some twelve feet thick); this separation in places presents for short distances two beds. The exposure at the Sharpton Place (C. No. 180), east of the Cemetery Hill, affords instructive aspects of these features. The Middendorf sands, disjointed with many erosion breaks, approach close to the fall line with an elevation above M. L. T. of 446; the Middendorf clays attain their maximum elevation above the sea level of 442 feet, 2.5 miles SW. of Miles' Mill, high up on the side of a valley formed of crystalline rocks. This deposit afforded many fossil leaves; a clay tongue 1.5 miles NE. of Langley and at an elevation of 373 feet above the sea level yielded such other specimens of fossil flora as were found in the Aiken Area (C. No. 210).

The Middendorf clay bed is the most extensively distributed approximately homogeneous member of the Cretaceous formations exposed in South Carolina. It is the only one of the Cretaceous kaolin beds that even roughly approximates regional continuity. The Hamburg upper clay bed depended upon essentially local conditions of protection and favorable sedimentation, which were more propitious for its formation in the Aiken than in any other area; probably in part for the reason that the kaolinitic shales and granulytes which contributed much kaolin to the Hamburg beds were immediately north of the Hamburg clay zone in the Aiken Area, blanketed in the Edisto Area, south of this zone in the Santee Area, and so remotely north of it in the Pee Dee Area that the kaolinitic sediments were contaminated in transit.

In the Aiken Area the Middendorf clay bed, with its upper limit at an elevation above the sea level of 442 feet at the head of Big Horse Creek, extended southerly with increasing thickness and width along a plane declining to an elevation above the sea level of 262 feet at Beech Island. Extensive degradation has divided the original bed into a number of more or less widely separated patches.

While there are several detached patches of the Middendorf clay near the fall line the main body prevails along Bridge Creek, on Cemetery Ridge (C. No. 185), on the plateau between Wise Creek and Town Creek (C. No. 150, C. No. 155, C. No. 165) (the main tributary of Horse Creek), and on the plateau between Big and Little Horse Creeks opposite Graniteville (C. No. 205). On Bridge Creek it is found at an elevation of 384 feet above the sea level in a bed eighteen feet thick, near China Spring (C. No. 195), where it is fine-grained and affords an exceptionally valuable potters' clay requiring the admixture of no other clay to produce excellent faience wares. A sharp plane of division in the bed of this clay with corresponding differences in character suggests the probability that the upper zone is Middendorf in contact with underlying Hamburg clay. Its outcrop is thence followed intermittently to Cemetery Hill (C. No. 183), where it becomes excessively gritty at an elevation of 399 feet. Passing around this ridge it is observed maintaining its gritty character as we ascend Wise Creek, along which it is occasionally observed; its most easterly exposure occurring at an elevation of 463 feet above the sea level in the town of Aiken, near Coker's Spring, where it is fine-grained, and beyond which it is obscured by the Eocene formation. Wells bored at Aiken with a surface elevation of 527 feet (above M. L. T.) reveal this clay twenty-five feet thick at a depth of ninety feet. Passing along the escarpment of the plateau south of Wise Creek it is exposed with gritty characteristics on the Hitchcock and Whitney Places, beyond which it appears with fine grain at the Harrigal Place and at the Immaculate and Peerless Mines, where it is twenty-five feet thick, with a surface elevation of 406 feet (M. L. T.). From this point, seven miles east of Hamburg, its outcrop sweeps around southwesterly to old Beech Island village, one-half mile east of which, at an elevation of 262 feet above the sea level, it appears in a six-foot bed underlying fifteen feet of very fine white stratified sands whose much eroded surface, with large kaolinitic balls emphasizing the unconformity, sustain Eocene sands and glauconitic conglomerates.

A gradual ascent for a mile east of Beech Island village leads to an Eocene ridge, at an elevation of 431 feet above the sea level, with a steep southerly escarpment on which buhr-rock is observed at an elevation of 367 feet above sea level (E. No. 20).

Proceeding to the mouth of Hollow Creek we find extending on both sides of this stream lignitic clays (E. No. 23), which continue on the southerly side for five miles from its mouth. Along Hollow Creek from its point of confluence with Town Creek the characteristic fine-grained laminated siliceous clays and other materials exclusively Tertiary are exhibited (E. No. 15).

Ascending Town Creek we first observe at an elevation of approximately 235 feet a bed of clay which is apparently of upper Hamburg equivalence (C. No. 125). The western side of this valley is largely obscured by sands; the eastern side affords characteristic littoral phases of the Eocene which within two miles of the head of the valley are observed overlying the Middendorf clays, greatly indurated in places by contact with the Eocene grit. The Middendorf clays occur here at an elevation of 400 feet above the sea level, in thick beds of good quality.

The Middendorf beds west of Graniteville, on the plateau between Big Horse Creek and Little Horse Creek, are exposed eighteen feet thick in the mines of the Sterling Clay Co. (C. No. 205), beyond which it gradually feathers out northerly, with an increase of color. On Schultz Hill in Hamburg village a limited bed of contaminated clay of possible Middendorf antecedents overlies Hamburg materials.

TERTIARY BEDS.

Lignitic clays, as previously noted, occur along the lower third of Hollow Creek and probably constitute one of the basal members of the Eocene on which purple, yellow, white and brown sands are superimposed (E. No. 23). Superior to these sands, banded yellow and mauve colored clays appear along the Town Creek side of the ridge which separates this creek from Hollow Creek. Near the westerly head of Town Creek a five-foot bed of slate-colored Eocene clay occurs at an elevation of 454 feet above the sea level (E. No. 110). The clay is soft in its bed, but readily hardens on exposure to the air; it underlies thirty-five feet of partly stratified sands with thin lines of clay interlaminated at the upper part; on the latter pebbles rest and support fifteen feet of red cemented Lafayette sands and a thin layer of cobbles and eolean sands with their surface at an elevation of 509 feet.

(On the opposite side of the Savannah River, at an elevation of 495 feet above the sea level, the equivalent of this Eocene clay occurs in a heavy bed with an included layer of sands affording fossil shells; the clay affording leaves of the dwarf palm, the alder, the willow and the bay. An analysis on the dry basis affords of silica 68.89 per cent. and alumina and ferric oxide 16.17 per cent. The shells were mainly in the form of casts of interdeterminate varieties of Turritellidae, Tellinidae, Veneridae and Ostracidae.)

At the head of Town Creek the Eocene grit rests in beds eight feet thick on some of the Middendorf clay exposures, and at these points the Middendorf clays have been greatly indurated (E. No. 11). Along both sides of the upper third of Hollow Creek the characteristic fine-grained laminated siliceous clays occur in deposits exceeding ten feet in thickness, and at an approximate elevation above the sea of 382 feet; these clays are separated by 46 feet of coarse sands from an underlying bed of buff micaceous clay, exposed in the bed of the branch at the Archie Dean Place (E. No. 15).

Passing from the head of Hollow Creek to the head of Wise Creek at Calico Springs (E. No. 5), at an elevation above sea level of 485 feet, we observe fossiliferous Eocene grit slightly superior to the much eroded surface of the Middendorf clay which appears at the level of 437 feet. Continuing to the head of Bridge Creek, at Beaver Pond (E. No. 7), the Eocene grit is found to assume the distinctive form of buhr-rock at the level of 435 feet, which elevation increases to 464 feet within two miles N. W. Many bowlders exhibit both the Eocene grit and the buhr-rock aspects, to which is often added the ferruginous sandstone feature. The buhr-rock affords here no distinctive fossils, but merely a silicified mass of comminuted shells. A further prolongation of this ascending plane encounters thick ferruginous sandstone at successive places for five miles, where the sandstone beds cease, with a thickness of fifteen feet at an elevation slightly exceeding 500 feet above the sea level (E. No. 8). (Locality 4.75 miles N. 29 W. from Cemetery Hill.)

The following section at Beaver Pond indicates the relation of the Eocene materials to the underlying Middendorf bed:

Survey Exposure, C. No. 195.

	Feet Thick.
Pliocene sands, thin clay seams and cemented red sands enclosing pebbles 1¼ at bottom	7.0
Fine argillaceous red sands, with curly whirls of lilac sand	8.0
Buhr-rock on terrace (elevation 435 feet)	4.0
Terrace of purple, yellow and red sands enclosing occasional dashes of clay	18.00
Dirty, yellow, loose, coarse sands	14.7
Mass of pebbles in firm, coarse sands	7.5
Undulating seam of iron cement enclosing quartz pebbles 1.5 inch	0.7
Erosion Plane—	
Middendorf white sands with thin seams of buff and white clay	9.0
Middendorf and Hamburg (?) Clay	18.0

Sand, clays and sandstone of highly probable Eocene equivalence are observed at the head of Clear Water Creek and immediately east of North Augusta, at an elevation of 459 feet above the sea level, underlying Lafayette red loams and cobbles.

The Lafayette loams occur near the upper surface of the more elevated plateaus of the Aiken Area and in places (some as far as six miles from the Savannah River) support beds of Lafayette cobbles at elevations varying from four hundred and fifty to five hundred feet, succeeding which eolean sands extend the elevation as the distance from the valleys increases.

OTHER CLAYS.

In the Savannah River Area of the Coastal Plain, outside of the distinctive clay zone pertaining to the Cretaceous and Eocene formations, there are beds of clay of economic importance, principally afforded by comparatively recent alluvial deposits along the streams deriving sediment from the Crystalline Region; although the breaking down of the Cretaceous and Eocene clays affords some workable deposits along streams originating south of the fall line. At North Augusta and Hamburg a large deposit of alluvial clays occurs, which is excellently adapted to the manufacture of brick and the coarser stonewares.

A zone of older clays occurs approximately parallel with, and about thirty miles distant from, the Coast, which is probably of Pliocene equivalence. These clays are often fine grained and vary in color from pale yellow to a mottled blue and are associated in many instances with coarse sands. Sixty feet approximates their average elevation above the sea level. These beds are characteristically developed near Garnett and are adapted to the manufacture of tiling, face brick, and common brick. In some localities their composition approximates that of fuller's earth, for which their use is not unknown.

THE EDISTO AREA.

GEOGRAPHIC LIMITS.

This area has the following bounds: On the north by the fall line, beginning at a point immediately north of Trenton and proceeding parallel with the Columbia and Augusta railway to the head of Twelve Mile Creek, north of Summit; on the east by an irregular line proceeding from the head of Twelve Mile Creek, by Summit, and thence southerly by the watershed between the Congaree and Edisto Rivers, on which divide the towns of Macedonia and Swansea are located, and extends thence by Creston, Eutawville and Bonneau to Bulls Bay; on the west by the crest of the watershed dividing the Edisto and Savannah River waters, the line of which closely follows the Edgefield-Aiken highway, passing by the head of Beaver Pond, and thence to Montmorenci, whence it follows the railway to Windsor.

PHYSIOGRAPHY.

The upper limits of this area attain an elevation of 650 feet above Mean Low Tide on the high ridge extending from Trenton to Summit, which is the northerly limit of the drainage system of the Edisto Area. From this ridge systems of plateaus extend southeasterly separated by the abrupt valleys of Shaw's Creek, South Edisto and North Edisto Rivers, which originate in extensive amphitheatre-like basins on the southern slope of the ridge. In one of the basins, a mile below Batesburg, the Edisto River headwaters are at an elevation of 594 feet (M. L. T.), with channels eroded to the crystalline rocks; at Seivern, 12.5 miles lower, this stream has a surface elevation of 310 feet (M. L. T.) and thence affords a comparatively uniform fall to tide water. The deepest incisions in the Edisto Area are afforded by the North Edisto River, but they are much more shallow than in the case of either the Savannah or the Santee Areas, where, at corresponding points, the rivers cut the formations 198 feet deeper. The Cretaceous or basal Coastal Plain formations of the Edisto Area are exposed, therefore, to a much more limited extent. The Cretaceous formations are less characteristically developed in the Edisto Area than in any of the South Carolina Areas; the area of the Crystalline Region which was tributary to the Edisto Area during the Cretaceous time was very limited and afforded no large streams. The Edisto system was largely a creature of the Coastal Plain, therefore without contamination by large volumes of fresh

water inimical to marine life, its marine waters at the close of the Cretaceous made relatively more northerly invasions with its fauna into the Edisto Area than was experienced by either the Savannah, the Santee or the Pee Dee Areas with their vast volume of fresh or brackish water, as is demonstrated by the distribution of the fossil fauna of the Eocene group.

CRYSTALLINE ROCKS.

Shales, mica-schists and gneiss are exposed by the headwaters of the North Edisto River at the head of Black Creek, Lightwood Creek and Chinquapin Creek intermittently over a band about two miles in width and five miles in length. The shales and schists strike N. 60 E., with a dip N. W. 75 degrees with the horizon, and enclose veins of quartz striking N. 30 E. The gneiss, which is south of these shales and schists, encloses in places oxydized cubes of pyrites.

COASTAL PLAIN FORMATIONS.

Small occurrences of clay, arkose and basal pebbles are observed on the crystalline rocks at the heads of the streams of this area, where exposed by erosion, but extensive beds of sands with intermittent layers of clay constitute the body of the Cretaceous formation exposed from the fall line to an oriental line extending from below Cook's bridge to Horsey's Bridge. Two beds of clay characterize this terrane. The upper bed, which in some places is highly purple in color, is observed at certain exposures overlying the other, with an intervening deposit of various sands 32 feet thick; in some gulches but one bed is found, and in many neither can be traced by either natural exposures or borings. Some parts of the beds are from five to thirty-five feet thick and of considerable economic importance. The upper clay bed probably corresponds to the Middendorf and the other to the Hamburg beds, but the abundant presence of pyrites in the lower bed imposes the probability of more saline waters than characterized the Hamburg of the Aiken Area.

The following analyses represent respectively the upper and lower clay beds of the Edisto Area:

Silica	46.99	45.69
Alumina	36.08	37.47
Ferric Oxide	1.02	1.01
Titanic Oxide	.86	1.44
Lime	Trace.	Trace.

Magnesia	Trace.	None.
Soda	1.09	.69
Potash	.20	.08
Ignition	13.82	13.98
Totals	100.06	100.36
Rational Analyses—		
Clay Substance	88.99	94.68
Soluble Silica	0.0	0.0
Quartz	4.53	3.76
Feldspar	6.54	1.92
Totals	100.06	100.36

These two beds are respectively exposed at the following elevations above the sea, proceedingly southerly from the fall line:

North Edisto Drainage System.

	Elevation. Upper Clay. Feet.	Elevation. Lower Clay. Feet.
Head of Black Creek	580	
Underlying the Eocene grit in basin 2 miles southerly from Leesville (C. No. 275)	568	
Railway cut 6 miles southerly from Leesville (C. No. 280)	448	
Steedman, 9 miles southerly from Leesville (C. No. 290)		360
Chalk Hill Creek, 10 miles southerly from Leesville (C. No. 295)	400	350
Marbone Creek, 11.5 miles southerly from Leesville (C. No. 298)		343
Juniper Creek, 12.5 miles southerly from Leesville (C. No. 300)	394	343
Sand Dam, 14.0 miles southerly from Leesville (C. No. 315)	390	
Giddy Swamp, 17.5 miles southerly from Leesville (C. No. 310)	283	
Cedar Creek, 20 miles southerly from Leesville (C. No. 320)	280	

High ridges south of Giddy Swamp and Cedar Creek, on opposite sides of the Edisto River, afford the upper limit of the main body of the formations which pertain to the succeeding Eocene, or oldest member of the Tertiary Era, whose junior members extend the Edisto Area to the seaboard.

South Edisto Drainage System.

	Elevation. Upper Clay. Feet.	Elevation. Lower Clay. Feet.
Two miles north of Merritt's Bridge (C. No. 268)	402	
One and one-half miles south of Merritt's Bridge (C. No. 255)	390	
Three miles south of Merritt's Bridge (C. No. 260)	389	320

The following sections show the relative positions of these beds:

	Thickness Feet.
Seivern—on Juniper Creek (C. No. 300)—	
Sands, enclosing thin seams and lenticles of kaolin on hill-side with a surface elevation of 406 feet M. L. T.	25
Upper layer of clay	5/18
Yellow and white sands	33
Lower layer of clay (elevation 343 feet M. L. T.)	40
Bed Juniper Creek in same (elevation 331 feet M. L. T.)	
Brodie Place, 3 miles South of Merritt's Bridge, on Hillside—	
Yellow clay, weathering to limonitic flakes and fragments	10
Brown sand, capped with huge bowlder masses of a ferruginous cement enclosing rounded pebbles and small kaolin balls	12
Brown and yellow argillaceous sands enclosing 12-inch kaolin balls along a plain of erosion	3
Very white and pink fine sands	8
Thin seam kaolin—coarse yellow sands supporting on inclined surface scattered Lafayette pebbles	18

	Thickness Feet.
Purple fine grained kaolin (elevation 389 feet M. L. T.)	5.1
White micaceous clay	6.3
Sands	32.5
White clay in well (elevation 345 feet M. L. T.)	26
Section at head of Little Black Creek, two miles S. W. of Summit—	
Pink colored Eocene grit at an elevation 593 feet (M. L. T.)	2
White argillaceous matrix enclosing rounded quartz pebbles 3-8 inch in diameter	.5
Compact clay of pale gray color	4
Micaceous clay	3
Section afforded by a gully entering the ridge one mile S. W. of Summit—	
Loose sands on the side of a steep hill with surface elevation of 650 feet (M. L. T.)	60
Salmon colored friable sands enclosing small balls of kaolin	7
White clay matrix enclosing rounded particles of quartz 1-8 inch; the whole weathering into rounded "hog backs"	10
Cream colored fine grained kaolin	3.1
Salmon and white colored sands	10

Shaw's Creek affords the usual Cretaceous sands and a few lesser seams of clay.

Black Creek reveals numerous small exposures of clay in Cretaceous sands, and near its confluence with the North Edisto River affords a deposit of the upper bed of kaolin of considerable prominence.

EOCENE.

Deposits of this formation extend their main littoral line east and west from Perry, which is located on a high ridge, extending intermittently at an elevation of 480 feet (M. L. T.) in an east and west direction. From the ridge several tongues extend northerly into the valleys of Cretaceous materials, forming along their escarpments littoral deposits, consisting of sands and Eocene grit, which in many places contain characteristic fossils of the Claibornian stage.

The North Edisto Valley affords most instructive exposures of the littoral members of the Eocene as well as economic beds of clay. The portion of the valley within the clay zone was studied in considerable detail. The ridge on which Batesburg and Leesville are situated, at an elevation of 656 feet above the sea, is separated by a thirty-two foot layer of the Neocene sands and clays from the subjacent crystalline rocks. Southerly a deep amphitheatre of nature formed by the sources of Chinquapin, Lightwood and Black Creeks appears; upon entering it are found, extending a mile from Batesburg, altered schists and shales, which have been eroded, within a half mile of Batesburg, with their valley line at 594 feet elevation (M. L. T.), and thence they ascend with the succeeding ridge, where they pass under the littoral margin of the Cretaceous beds.

Proceeding from Leesville S. 20 E. along a tributary dale to the valley of Lightwood Creek at a distance of one mile, and at an elevation of 651 feet (M. L. T.), are found detached ledges of a very hard sedimentary quartzose rock, six feet thick, along both sides of Marlow Branch. It represents an aluminous matrix, firmly cementing in horizontal layers alternate coarse-grained and fine-grained sands and scattered angular fragments of very hard kaolinitic matter, also occasional scales of muscovite.

This Eocene grit has been quarried for probably a century, and used for structural purposes. At a distance of about 2.25 miles S. E. from Leesville there is a long ledge of it, and at a distance of three miles it appears capping a series of detached knolls rising twenty feet above the base of the basin with their flat tops at an elevation of 574 feet above the sea (E. 255).

The following is a section of one of these knolls, as exposed at the old Keesler Place, with a surface elevation of 574 feet (M. L. T.): Eocene grit or silicified arkose, with zone of lamination along which it readily splits, 6.0 ft.

Coarse, sub-angular grained quartzitic rock enclosing indurated lumps of subjacent equivalents, 0 to 2.8 feet.

Very hard clay, with difficulty scratched with knife; becoming softer with depth (Cretaceous partly silicified by Eocene contact), 10 ft. and more.

Talus obscured lower part of section.

Similar exposures of Eocene grit are observed at an elevation of 574 feet along a ridge at the head of Hell Hole Branch, three miles from Leesville, and extending over a distance of a half mile (E. 257). The underlying clay, where protected, is readily cut with ordinary implements, but when exposed to the air becomes as hard as novaculite, which it resembles. It apparently contains liquid silicic acid, through the action of which the littoral members of the Eocene formation have been hardened, and the underlying Cretaceous clays impregnated and indurated, the range of action decreasing with depth. Analyses of these eocenized Cretaceous clays, and of the Eocene clays of Mr. Tuomey's buhr-stone stage, show a considerable percentage of soluble silica (as much as 19 per cent.). The Eocene grit also occurs at the head of Black Creek, in marginal deposits. Following the plane of this quartzose formation down the Edisto Valley, it is found exposed 2.25 miles N. 55 degrees W. of Seivern (E. No. 260), at an elevation of 493 feet (M. L. T.). In the distribution of contained materials it resembles the Keesler bed, but contains less aluminous matter, and shows cores of pure chalcedonic quartz enclosing exquisitely preserved casts and molds of Eocene shells, and a liquid silica which within a quarter of an hour after exposure to the air congeals to a friable white mass. The fossils are sparsely distributed throughout the entire mass of materials. No bed of clay has been observed associated with this exposure. A small quantity of this rock occurs 1.1 miles east of Seivern at Three Cornered Pond (E. No. 262), at an elevation of 453 feet (M. L. T.). A considerable bed of the highly siliceous laminated mass of characteristic buhr-stone clay is exposed at this point.

Proceeding 2. 5 miles east of Seivern it is again observed on the hillside one mile from Sand Dam Bridge (E. No. 265), at an elevation of 441 feet (M. L. T.). It is not again observed before reaching the head of Good Land Swamp (E. No. 270), one mile S. E. of Perry, where at an elevation of 321 feet a hard arenaceous ledge of rock similar to the Gunter exposure is found containing a few fossils; but about 2,000 feet south, at an elevation of 311 feet (M. L. T.), the rock becomes a mass of white silicified Clabornian shells, which is exposed intermittently onward to the Froman Place on Rocky Swamp.

Good Land Swamp on the west is separated from Dean Swamp by a ridge which, at Sallys, is about two miles wide. On Dean Swamp opposite Sallys, on the place of Mr. Demps Sally (E. No. 272), the Eocene grit is again observed on the side of a hill, at an elevation of 245 feet (M. L. T.). About 1,000 feet south of this exposure, at an elevation of 223 feet (M. L. T.), a thin bed of the Ostrea Johnsoni was discovered bedded in compact coarse sands. Intermediate to these exposures there occurs in a deep gully at an elevation of 235 feet (M. L. T.), a ten-foot exposure of stratified brown, red and white sands containing bunches of broken lines of lignite. At a second intermediate point a gully with almost vertical sides deeply cut into the hill below the horizon of the Eocene grit reveals no shells of the Ostrea Johnsoni, and shows the grit feathering out to nil. The beds of Eocene grit and shells in this region I construe as estuarine in character, for the reason that they occur in narrow basins and along the sides of valleys, whose flanking hills they fail to penetrate at any exposure characterized by the Eocene grit feature.

The discussion of other exposures of the Eocene beds of the Edisto should be deferred until the subject of marls is undertaken. The introduction of the foregoing details in this report will be understood from the fact that this grit is at other points so intimately associated with the extensive beds of clay that the determination of its horizon as Eocene will facilitate the correlation of the elsewhere associated clays.

Along the South Edisto Valley definitely characteristic Eocene formations are not found until we proceed south of Cook's Bridge, although sands and conglomerate sandstone of probable Eocene equivalence extend much higher.

Along Shaw's Creek, Eocene buhr-rock is found as far north as the depression which connects through a distance of five miles with the head of Beaver Pond of the Aiken Area, where similar rock is freely exposed.

The Eocene grit, the buhr-rock into which it graduates, and the fuller's earth, constitute the main mineral source of industrial possibilities in this formation.

NEOCENE.

Excepting a few yellow and mottled clays and occasional occurrences of the typical Lafayette loams, no beds of the Neocene series are observed in the upper part of the Edisto Area, and the clays and loams are not susceptible of any definite discrimination. Lafayette pebbles of the vein quartz type are observable scattered here and there in a very few localities. Along the part of the Coastal Plain immediately within the zone of our sand islands and extending intermittently over the section ramified with bayous and other short salt water streams there occurs a mantle of red and white stratified clay, parts of which are very fine-grained and most of which affords a very fair brick clay. It varies from 0 feet to 34 feet in elevation above the sea level. It is probably of late Pliocene equivalence. Clay from these beds has been employed in the neighborhood of Charleston for more than a century in the manufacture of brick and of tiling.

THE SANTEE AREA.

GEOGRAPHIC LIMITS.

The fall line which bounds this area on the north begins at the head of Twelve Mile Creek, proceeds along that stream to the Saluda River and crosses the Congaree immediately north of Columbia, extending to the Crane Creek Bridge on the Monticello highway; thence follows the northerly prong of Crane Creek to its head, crossing the Columbia and Charlotte Railway near the seventeen mile post; thence it follows Twenty-four Mile Creek to the Wateree River and proceeds, with a highly meandering course for approximately five miles, up Sanders Creek, and thence near Westville towards Kershaw, where it enters the Pee Dee Area.

The watershed bounding the area on the east extends from Westville by Cassatt, and thence by Providence, Wedgefield, Pinewood, and Lanes to the ocean. The watershed bounding it on the west extends from the head of Twelve Mile Creek by Summit, Macedon, Gaston and Creston, and thence southeasterly to the ocean at Bulls Bay.

PHYSIOGRAPHIC FEATURES.

The high ridge previously noted as limiting the Edisto Area on the north finds its equivalent in the Santee Area, but is interrupted by the deep valleys of the Congaree and Wateree Rivers, which cut through it as indicated by the following elevations above the sea level:

Summit	620	feet.
Congaree River (C. & A. Bridge)	109.6	feet.
Ridge between Congaree and Wateree Rivers	625	feet.
Wateree River (S. A. L. Bridge)	125	feet.
Ridge between Wateree and Pee Dee Areas	597	feet.

In addition to the three main plateaus which extend southerly respectively from Summit, Killian and Kershaw, there are two prominent ridges, which during the Cretaceous times constituted flats subsequently surrounded and partly covered by Eocene materials.

An inspection of the part of the Coastal Plain drained by this area shows that the watersheds on either hand are parallel to and close to the river line, from which their average departure does not exceed ten miles; and that the drainage system between the Congaree and Wateree Rivers radiates from Killian. The Santee River system derives practically no water from either the Crystalline Region or the Coastal Plain Area on its east. The watershed between the Santee and Pee Dee Areas constitutes a dividing ridge in the geological structure of South Carolina. All of the streams crossing the fall line, and nearly all originating near it, expose the Crystalline rocks near the bottom of their valleys.

CRYSTALLINE FORMATIONS.

Proceeding from the fall line southerly, occasional characteristic exposures of Crystalline formations in the valleys reveal successively granite, slates, schists, shales, granulyte, and granite. The shales affording the valuable meta-residual clays occur intermittently from Killian to Dent's Pond, on Gill's Creek, a distance of seven miles; they are also exposed along Twenty-five Mile Creek and its tributaries, on the Camden bank of the Wateree River, and again north of Sanders Creek. The strike of these shales varies from N. 30 E. to N. 68 E., and their dip from 50 degrees to 90 degrees with the horizon. At one time horizontal, they now appear to have been doubled up in a trough by pressure of granitic rocks from the southeast.

These southerly granitic rocks are extensively quarried below Columbia, the northerly granite being quarried above Ridgeway and near Liberty Hill. In places the disintegrated shales represent beds of great economic importance, valuable for bonding the refractory sedimentary clays; some burn quite white. The composition of one type is exhibited in the following analyses:

Silica	53.19
Alumina	33.41
Ferric Oxide	1.67
Titanic Oxide	.37
Lime	.10
Magnesia	.25
Soda	.12
Potash	.66
Ignition	10.63
Total	100.40

Rational Analysis:

Clay Substance	86.71
Soluble Silica	0.00
Quartz	12.65
Feldspar	1.04
Total	100.40

COASTAL PLAIN FORMATIONS.

The lowest Cretaceous stages probably find no exposures in this area superior to the valley lines, their littoral lines having been at lower levels; but that portion of the following comprehensive section which represents a well at Wedgefield indicates that the Potomac equivalent probably occurs 101 feet below the sea level. The upper 150 feet of this section, comprising the Lafayette, Buhr-stone, and in part the Upper Cretaceous formations, has been consolidated from the neighboring exposures intervening from Wedgefield Ridge to the Wateree River.

Wedgefield Cut and Well (C. No. 603).

	Thickness. Feet.	Elevation. (M. L. T.) Feet.
Lafayette loam	6.0	265
Red sandy clays enclosing few small rounded pebbles	0/15	
Gray argillaceous compact hard coarse sands	0/30	
Pronounced plain of unconformity		259
Eocene Fuller's Earth (enclosing casts)	10/20	
Thin layers of drab clay interlaminated with sands slightly lignitic at base and occupying depressions in the underlying unconformable material	0/7	
Marked unconformity		232
Coarse sand with some glauconite. In places ascends in unconformable peaks 15 feet high into overlying materials	5/15	
Clay-iron stone and brown sand conglomerate, resulting from decomposition of glauconite	1.5	
Greensand marl	17.5	
Consolidated mass of greensand interlaminated with iron-stone, drab clay, orange and yellow sands, mixed, angular and coarse sands	11.0	
Unconformity		197.6
Coarse, yellow clay, enclosing rounded gravel	1.5	
Angular fragments of feldspar and quartz in clay matrix	1.5	
Purple and gray clay, containing much iron pyrites	8.0	195
Sands, etc.		129

Pee Dee River low water level 89 feet.

The following data derived from Well section—
Sands and clays, amounts unrecorded—

Very dark lignitic clay, enclosing large pieces of wood	25.0	(-)101
Interstratified sands, clays and arkose	195.0	(-)321
Very hard rock arrested work at	12.0	(-)333

No water at this horizon.

The upper Cretaceous formation finds its southerly limit just above Buckingham Bluff on the Santee River and extends thirty-five miles northerly to the fall line. But while it is thus exposed along the water courses the Eocene formation blankets it on the plateaus and in the pre-Eocene basins, although some portions of Cretaceous ridges rise superior to the surrounding Eocene deposits, as occurs west of the Congaree River and east of the Wateree.

The materials of the Cretaceous comprise sands of all hues, massive and cross-bedded, and afford extensive beds of kaolin and other high-grade clays. Of these clays there are several seams of importance in the Santee Area. The lowest of the consistent seams is exposed at Congaree Bluff and at Cook's Mountain, a few feet superior to the water level under which it gradually disappears southerly.

Above this seam there are two zones of Cretaceous clay, each of which was formed in the protected portion of the erosion areas found by their respective waters; therefore these two beds of clay are by no means invariably found in immediate superposition.

The upper bed consists of a very compact clay that is often white with an almost invisible yellow green shade, but is more frequently a very light drab and pink, which bleaches to a pure white on drying. This bed corresponds to the clay heretofore designated Middendorf.

Its plane of deposit was highly irregular, with the result of frequently causing it to be deposited at high angles and at sundry elevations. The lower bed, which is separated from the upper bed by fine and coarse white and colored sands of variable thickness, consists of an exceedingly fine grained and often white clay, although it is frequently stained purple by contained organic matter. This bed probably corresponds to the upper Hamburg bed of the Aiken Area, but is less conspicuously developed. Succeeding these formations southerly, the Eocene clays and fuller's earths are observed, followed by mixed and less important clays pertaining to the end of the Tertiary, which are observed extending about thirty miles from the coast.

The high ridge west of the Congaree River constitutes the easterly margin of a series of prominently depressed basins formed by the sources of Congaree Creek, which flows northeasterly in quest of the Congaree River. The Red Bank Creek reveals the crystalline rocks underlying Cretaceous sands and unimportant beds of clay, which command no special geologic interest. The head of the tributary maintaining the name of Congaree Creek ramifies a large basin, whose escarpments show Cretaceous sands and prominent beds of Eocene grit, which in some places are immediately superimposed on the clay (Noah Lucas Place and Rock House, C. No. 500, C. No. 503).

The slopes of Sand Mountain on the south side of the basin expose, at an elevation of 430 feet above the sea, some very white and pink clays of pisolitic form, but of highly uncertain extent. Crossing the Sand Mountain ridge, red and yellow colored sands and clays are found, mantled by beds of fine-grained eolean sands which exceed twenty-five feet in thickness. In a well at Edmonds a three-foot bed of pisolitic clay was observed at a depth of thirty-one feet, or 432 feet above the sea (C. No. 504). The abrupt depression formed by First and Second Creeks extends southerly in a basin about four miles in diameter, encircled on the west by a ridge separating it from the Edisto waters, and on the south by a plateau, the previously noted Cretaceous ridge constituting its easterly rim. The valley lines of this basin are at 157 feet elevation above the sea at the northerly outlet, and at 308 feet at its southerly origin. The encircling ridges ascend to a height above the sea of 600 feet on the north, of 533 feet on the west, and 478 feet on the south, and exceeding 500 feet on the east.

Scattered over this basin is a series of low knolls and ridges, some of which (at an elevation of 373 feet) include thick beds of the pink, red and drab clays of Middendorf lithological equivalence, capped in places with Eocene grit. The escarpments are constituted of the Cretaceous vari-colored sands, enclosing small seams and lenticles of clay, the whole being without stratigraphic consistency up to, within, a hundred feet of the top, where the materials are approximately stratified as fine red, brown and white sands, with occasional clay lines, all being surmounted by Lafayette cobbles and loams and eolean sands.

There are two marginal chains of rock intermittently shown on these escarpments. The upper is composed of a ferruginous sandstone; the lower is the Eocene grit, which attains the thickness of eight feet. Along the north of the basin, at the head of Second Creek (E. No. 510), and at an elevation of 503 feet, the Eocene grit is fossiliferous. Along the eastern margin at the head of First Creek the Eocene grit is eighty feet below the sandstone, which occurs in ledges twenty-three feet thick. Neither of these ledges penetrates the hills, they evidently having been littoral formations, on the Cretaceous materials, except at the southeastern corner of the basin, where there was a pre-Eocene break which extended southeasterly to the main Eocene basin, now filled with characteristic Eocene fossiliferous clay and grit, with their surface elevation at 405 feet above the sea (E. No. 505). This clay is the lithological and biological equivalent of Mr. Tuomey's "Siliceous Clay" of the Buhr-stone formation, although considerably north of the point to which he traced it; the locality under consideration being one mile northwest of Gaston, under which place the Eocene extends.

Proceeding from the mouth of Congaree Creek along the eastern escarpment of the Congaree Ridge, the characteristically involved succession of sands and inconsequential beds of clay appears until the Geiger Place is reached (C. No. 515), where, at an elevation of about 340 feet, a very prominent exposure of superior kaolin, of apparent and analytical upper Hamburg equivalence, occurs in a bed twelve feet thick.

The following analysis indicated the character of this clay:

Silica	45.44
Alumina	38.78
Ferric Oxide	1.15
Titanic Oxide	.98
Lime	.11

Magnesia	.12
Soda	.48
Potash	.23
Ignition	12.86
Total	100.15

Rational analysis:

Clay substance	97.86
Soluble Silica	0.00
Quartz	.93
Feldspar	1.36
Total	100.00

Procceding southerly, mixed clays extend this clay zone in detached patches with their average plane declining towards Congaree Bluff, one mile west of which on the place of Mr. Archie Wolfe (C. No. 520), at an elevation of 208 feet, a bed of fine-grained purple clay eighteen feet thick occurs. At Congaree Bluff (C. No. 525), where the river elevation is 101 feet, a layer of dense drab clay, eight feet thick, is observed, with its surface twenty-seven feet above the river, under which it gradually declines southerly.

From the Archie Wolfe Place (north of Sandy Run) the Eocene supervenes in thick beds of fossiliferous siliceous clay and sands, which mantle the Cretaceous southerly and westerly. Following the line of hills down the right of Congaree Swamp the Cretaceous clays are occasionally revealed as far down as the Santee River, but the amount of overburden precludes economic susceptibilities.

Starting at the head of Crane Creek (C. No. 550), the most northerly tributary of the Congaree River draining the Coastal Plain from the east, we observe east of Killian and slightly above the crystalline rocks, at an elevation of 412 feet above the sea, a bed of kaolin, varying from five to more than fifteen feet in thickness, which constitutes a superior and self-sufficient fire clay of which the following is an analysis:

Silica	42.30
Alumina	36.94
Ferric Oxide	2.64
Magnesia	.78

Lime	.80
Ignition	15.43
Alkalies and Undetermined	1.1
Total	99.99

This deposit extends towards Columbia in a much contaminated bed of variable thickness and intermittent exposures. In Columbia excavations at the yards of Seaboard Railway expose beds of clays (C. No. 555) separated from the underlying gneiss by arkose and angular quartz. The upper portion of the gneiss under cover is decomposed for twelve feet. The character of the clays improves as the beds recede from the Congaree Valley line.

The plane of this clay projected from Killian to Dent's Pond is in close superposition to the crystalline shales and meta-residual clays which are exposed at many places through erosive influences. These meta-residual clays are utilized for bonding the highly refractory Hamburg clays of the Santee Area at the Landrum Fire Brick Works (C. No. 563), near Gill's Creek.

Gritty and colored clays are exposed at several points along the west side of Gill's Creek and its westerly tributary in beds varying from four to ten feet in thickness. The Landrum Fire Brick Plant is supplied from one of these refractory beds of clay. A thick bed of the gritty clay occurs on the Garner Ferry Road in the valley of the creek.

The ridges between Gill's Creek and Cedar Creek are to a great extent masked with Lafayette loams and sands and occasional beds of cobbles of vein quartz and quartzite.

On the Garner Ferry Road, seven miles from Columbia, there is an exposure of the Middendorf clay (at an elevation of 215 feet), eight or more feet in thickness and of characteristic density, color, composition and order of superposition (C. No. 565). Its composition is indicated by the following analysis:

Silica	49.31
Alumina	34.38
Ferric Oxide	1.91
Titanic Oxide	1.10
Lime	.18
Magnesia	.16
Soda	.21

Potash	.20
Ignition	12.52
Total	99.97

Rational Analysis:

Clay Substance	91.72
Soluble Silica	0.00
Quartz	7.16
Feldspar	1.09
Total	99.97

At Cedar Creek we observe extending up and down the creek a deposit of superior pure white kaolin varying from nil to twelve feet in thickness at an elevation of 235 feet above the sea (C. No. 570). This deposit intermittently extends down Cedar Creek, declining to the verge of the Congaree Swamp, but increases in content of grit and color as it approaches the main valley line. There is nothing of an instructive character in its associate sands, etc., except that from the Smith Place southward the Pliocene has greatly eroded this seam, and in places has left its deposits in contact therewith. An analysis of this clay revealed the following composition:

Silica	45.72
Alumina	38.96
Ferric Oxide	.93
Titanic Oxide	.98
Lime	.06
Magnesia	.07
Soda	.55
Potash	.19
Ignition	13.05
Total	100.51

Rational Analysis:

Clay Substance	98.39
Soluble Silica	0.00
Quartz	1.21
Feldspar	.91
Total	100.51

The valley of Thom's Creek affords gritty high colored clay, without immediate interest. Carter's Creek drainage exposes, a half mile below Acton, a prominent bed of Middendorf dark drab clay at an elevation of 124 feet above the sea (C. No. 575). Following its southerly trend this bed is found exposed at intervals along the lower part of the Wateree River, below the level of which it gradually declines with an overburden of clastic materials aggregating forty feet in thickness.

Proceeding from the Columbia-Wilmington Railway bridge up the western bank of the Wateree River we observe several unimportant fractional exposures without stratigraphic coherence until we arrive at Cook's Mount, a high knoll 8 miles north of Acton, terminating in an abrupt bluff adjacent to the river. The bluff affords the following section:

Cook's Mount (C. No. 600).

Bluff Adjacent to River—	Thickness. Feet.	Elevation. (M. L. T.) Feet.
Ferruginous sandstone capping top of bluff	2.50	240
Salmon and orange colored sands enclosing diagonal lines of kaolin balls, sub-angular sand and scattered particles of hornblende	8.75	
Drab colored clay, dense and gritty	7.70	229
Kaolinitic matrix, pink at top, enclosing very white sand and some mica	4.00	
Mongrel mass of salmon, lilac and purple colored sub-angular gravel, 3-16 inch	2.00	
Thin seam micaceous drab clay	.30	
Brown, purple and pink sands, 3-16 inch, coarse at bottom	5.00	
Erosion Plain		210
Cream colored kaolins, gritty at top, micaceous and pink at bottom	16.00	
Mealy, white, fine sands, with pink streaks	9.50	
Plastic drab clay	.60	
Pink, mealy sands	3.25	
Yellow, coarse argillaceous sands	3.00	
Yellow, white, purple and red sands, cross-bedded	2.50	

Mealy white and gray micaceous sands, with cross-bedded pink streaks..	16.25	
Coarse purple and cream-colored sands, enclosing kaolin balls, 3 inches..	1.25	
Plain of Erosion..		146
Drab slate-colored kaolin		
Wateree River..		100

At Gilmore Hill, about 3 miles north of Cook's Mount, an instructive exposure occurs along a series of terraces, of which the following is a section:

Gilmore Hill (C. No. 605).

	Thickness in feet.
Ferruginous sandstone capping..	1.35
Hard mass of fine-grained brown and red sands, enclosing pebbles, 3-4 inch..	5.00
Fine grained deep red argillaceous sands..	
Very fine red and yellow horizontally and stratified sands..	25.60
Thin horizontal seams of yellow, red and gray clays, interlaminated with sands..	4.00
Indurated Fuller's Earth, laminated..	5.00
Brown, red, drab, white and Sienna-colored bands of sands..	7.00
Quartz pebbles, 1 inch, and kaolin balls in argillaceous sand matrix..	1.00
Pronounced unconformity, probably separating Eocene from Cretaceous.	
Drab-colored clay, very fine grained, dense, and unctuous (Middendorf)..	6.00
Coarse rounded sand in sticky white clay matrix.. ..	3.00
Pronounced Plain of Erosion.	
Moderately white, gritty kaolin, exposed (Hamburg)..	9.00
Formation concealed..	31.00
White fine grained kaolin..	3.00
Deep purple fine grained kaolin..	10.00

North of this point the exposures are insignificant in importance and interest until we arrive at the Eight Mile Post on the McCorde's Ferry Roard (C. No. 615), where the following exposure may be seen, with its beds pitched at high angles:

	Thickness in feet.
Eolean fine sands.	
Coarse yellow sands.	
Lafayette cobbles (elevation M. L. T. 185 feet)..	3.10
Drab and gray micaceous, gritty clay..	1 to 8.04
Middendorf pale clay, with plane highly pitched..	6.00
Ferruginous plates in micaceous sands..	1 to 5.00
Mixed clay..	6.00
Drab and purple clay..	4.00

Above this point the character of the formation is largely obscured by sands and cobbles except at Gillis's Ditch and Rice Creek, where the underlying white beds of mixed white gritty clays of probable Hamburg equivalence are exposed at an elevation of 161 feet above the sea.

Along a section extending up Colonel's Creek from its mouth, which is below Cook's Mount, nothing of striking interest is observed until we enter the tributary valley of Jumping Run. The south side of the valley exposes (at an elevation of 324 feet) an eight-foot bed of coarse gritty purple clay, underlying eleven feet of fine white sands beautifully banded with delicate shades of red, yellow and brown (C. No. 586). The clay, in turn, underlies a seam of semi-plastic red sands, which support a seven-foot bed of indurated fuller's earth, probably of Eocene equivalence. In further ascending order occur semi-plastic argillaceous sands, argillaceous sands interstratified with thin seams of drab clay, fine red sands, unconformity pebbles, harsh coarse case-hardened red sands, and finally a cap of yellow arenaceous clay weathering to prismatic fragments.

The ridge north of Jumping Run (Thompson Place) affords (at an elevation of 324 feet) very prominent deposits of clay, which represent two beds in contact aggregating thirty-one feet in thickness (C. No. 590). The clay of the upper bed (11 feet thick) is drab and purple in color, moderately hard and breaks with a conchoidal fracture; that of the lower bed is white, plastic, fine grained and in places slightly micaceous. The Middendorf and Hamburg clays are apparently in contact at this point. The lower part affords the following analysis:

Silica	47.78
Alumina	37.26
Ferric Oxide	1.26
Titanic Oxide	1.07
Lime	.07
Magnesia	.11
Soda	.63
Potash	.10
Ignition	12.29
Total	100.57

Rational analysis:

Clay Substance	95.48
Soluble Silica	0.00
Quartz	3.17
Feldspar	1.92
Total	100.57

On the Wire Road east of Colonel's Creek the Middendorf clay is again exposed at an elevation of about 350 feet, in a bed of pink and gray colored clay, seven feet thick.

Along the ridge north of the area of origin common to Gill's Creek, Colonel's Creek and Spear's Creek, which ridge is limited on the north by the upper branch of Crane Creek and by Twenty-Five Mile Creek, there are numerous exposures of the Middendorf clays adjacent to the Columbia-Camden Railway, at elevations varying from 270 feet to 320 feet above the sea, as may be seen at Thomas's Cut and in wells at Jacob's Station and near Blaney's (C. No. 593), also at intermediate points, the thickness of the bed varying from three to fifteen feet. These beds are much whorled and whereas their aggregate extent is considerable no very extensive individual beds were observed.

An examination of numerous lesser exposures along Spears' Creek revealed nothing of immediate interest. Along the north side of the valley of Twenty-Five Mile Creek a few unimportant marginal patches of clastic materials are observed, but this creek practically limits the Coastal Plain formations on the north. Meta-

residual clays are prominently exposed at Horse Pen Creek, south of Twenty-Five Mile Creek.

Proceeding up the eastern side of the Santee and Wateree Rivers from Fuller's Earth Creek (E. No. 590), we, at the outset, observe at an elevation above the sea of approximately 130 feet a bed of slate colored laminated siliceous clay more than thirty feet in thickness, containing fossil casts indicative of the claibornian phase. (?)

This Eocene clay extends northerly at the following successive localities with elevations above the sea level indicated in feet:

Rocky Point (C. No. 625)	160 ft.
Wedgefield Cut (C. No. 630)	260 ft.
Spring, 1.5 miles north of Wedgefield (E. No. 633)	299 ft.
Statesburg (C. No. 635)	269 ft.
Marden (E. No. 637)	251 ft.

An erosion valley causes a break beyond which, on the high hills near Smithville, the littoral aspects of the Tertiary occur at an elevation of 337 feet. This Eocene clay is distinctly fossiliferous at the above indicated spring; local information indicates fossil leaves as having been found in this clay where penetrated by wells.

An inspection of the Wedgefield section shows this bed separated from the underlying Middendorf clays by the bed of green sand marl elsewhere differentiated as Upper Cretaceous, which declines easterly, underlying much of the Pee Dee Area. This is the most westerly exposure of this marl observed in South Carolina and this immediate neighborhood affords its only exposures in the Santee Area. The relative positions of the Middendorf and Eocene clays are feebly shown at Rocky Point, of which the following is a section, and from which it will be observed that the Cretaceous green sand marl is absent:

Rocky Point (C. No. 625):

Lafayette red cemented sands.

White sands.......................23.0 ft.

Eocene siliceous clay with bottom conforming to irregularity of underlying bed.......... 7.0 ft.

Unconformity—

Fine white sands, coarse white sands, yellow and bright orange sands.............14.0 ft.

Orange sands interlaminated with broken lines of limonitic plates coated with clay and affording impressions of Dicotyledenous leaves.. .. .. 9.0 ft.
Irregularly bedded white, purple, pink, and drab clay enclosing yellow and white sand pockets.. ..15.0 ft.

Elevation of base of section 115 feet (M. L. T.).

From this point the Middendorf clays are successively exposed northerly at the following places and elevations above the sea: Rocky Point, 115; Wedgefield Cut, 195; Statesburg foothills, 219 feet; Rafting Creek Valley affords occasional evidence of these clays from Rembert's Mill (C. 640) to its source at elevations progressively varying from 180 feet to 240 feet above the sea level; Camden-Sumter Road, seven miles from Camden, 220 feet (C. No. 645); Shannon Hill, 255 feet (C. No. 648); head of Pine Tree Creek, 290 feet (C. No. 675).

The beds of Middendorf clays indicated above vary from seven to fifteen feet in thickness. Their prevailing colors are drab, pink and slate, which largely bleach to white on exposure to air and light. Each of these beds includes slightly gritty zones, which should exact washing to secure admission to the market.

The Hamburg clays occur at an elevation above the sea of 170 feet, slightly superior to the crystalline shales at Camden (C. No. 655), and on the south side of Sanders Creek (C. No. 670), in deposits varying from nil to seven feet in thickness.

THE PEE DEE AREA.

GEOGRAPHIC LIMITS.

This area is bounded on the north by a part of the fall line, which, beginning at Pleasant Hill, passes by the head of Buffalo Creek, crosses Lynch River Valley near the mouth of Tiller's Fork Creek, and thence proceeds in a curved line, passing about three miles north of the confluence of Black Creek with Little Black Creek, above which point a prominent tongue extends towards Hornsboro; east of Black Creek it extends by Ruby, by Chesterfield, and along Goodman's Creek to the Great Pee Dee River—White's Creek constituting its approximate limit thence to the North Carolina line. While a few patches of thin beds of sedimentary material extend above this line, many of the valleys expose considerable areas of crystalline deposits below it; conspicuously along the valleys of Thompson Creek and the three upper prongs of Bear Creek.

The North Carolina State line limits the Pee Dee Area of South Carolina on the northeast to the shore of the Atlantic Ocean. The area is limited on the west by the line before indicated as separating it from the Santee Area, and which extends from Pleasant Hill by Cassatt, Smithville, Wedgefield and Sumter to Lanes and thence to the ocean.

PHYSIOGRAPHIC FEATURES.

The profile across the upper part of the area is highly irregular, the following elevations above the sea level representing the more pronounced irregularities: Ridge between Wateree and Lynch Rivers, 597 feet; Lynch River, 220 feet; ridge between Lynch River and Great Pee Dee River, 510 feet; Pee Dee River, 50 feet; ridge at head of White's Creek, 325 feet (approximate).

A zone of the area about twenty-five miles wide, limited on the north by the fall line, affords very abrupt and pronounced changes of topography, exhibited by high hills, peaks, and plateaus enclosing deep valleys and basin-like areas. Many of these plateaus of sedimentary sands exceed the elevation of 500 feet above the sea, but along the lower limit of the zone they rapidly decline to a plain, of less than 200 feet elevation, which extends south of a line from Lucknow to Bennettsville and east of the Scapo tributary of Black River. West of this plain, and in extension of the more elevated topography of the rugged zone, a high range of hills extends southerly into Clarendon County, with prominent scarps facing the Wateree and Santee Rivers, but with a pronounced break in their continuity near Providence, in Sumter County, through which a water channel probably prevailed till the close of the Tertiary. The rugged zone on the north and the elevated range on the west thus partly encircle the plain, across which their elevations graduate southeasterly to the sea level, in conformity with the dip of the underlying marls, clays, etc.

The portions of the beds of the Great Pee Dee and Waccamaw Rivers which are embraced by the plain have a very slight fall, and the influence of tide extends therefore about one hundred miles up their courses from the ocean. The elevation of low water at the Great Pee Dee Bridge east of Florence is only twenty-one feet above the sea level; the bluffs and highlands adjacent to the stream and swamps are thirty to eighty feet higher. The Great Pee Dee and Lynch Rivers are the only streams in the area which originate on the crystalline rocks; the Waccamaw, Little Pee Dee and Black Rivers are essentially creatures of the Coastal Plain. Lynch River, which courses along the eastern part of the more elevated portion of the area, has a less depressed bed than its neighbors and makes shallower incisions into the Coastal Plain formations.

CRYSTALLINE ROCKS.

Near the fall line the crystalline rocks appear as shales whose upper parts, to a depth of one to twelve feet, have in many places disintegrated into very white and red plastic clays; especially prominent is this feature at Ruby, at Chesterfield and along Goodman's Creek. These shales vary in their strike from N. 57 degrees E. to N. 79 degrees E., and dip N. W. from 60 degrees to 90 degrees with the horizon. They, or the more southerly gneissoid rocks, are more or less in evidence along the upper parts of Buffalo Creek, Little Lynch Creek, Black Creek, Rocky Creek, Tiller's Fork, Bear Creek, Thomson Creek, and along the Great Pee Dee River north of Cheraw.

The following are typical analyses of the two grades of meta-residual clays from this area:

Silica	67.38	61.62
Alumina	20.49	23.82
Ferric Oxide	2.72	3.38
Titanic Oxide	1.12	1.19
Lime	.14	.33
Magnesia	.81	.39
Soda	.09	.72
Potash	2.55	1.43
Ignition	5.08	7.58
Total	100.38	100.46

Rational analysis:		
Clay Substance	54.83	59.68
Soluble	0.0	0.0
Quartz	38.34	28.08
Feldspar	7.21	12.70
Total	100.38	100.46

COASTAL PLAIN FORMATIONS.

The beds of Hamburg equivalence are exposed to a very limited extent in the Pee Dee Area. Between the fall line and a parallel line six miles south of it, isolated thin patches of unimportant clays occur enclosed in sands of brown, orange, yellow and white colors, with an underlying layer of cemented sand enclosing fragments of slates, and with pebbles superimposed unconformably on the surface of the shales and slates. At Cheraw, just south of the indicated zone, a twelve-foot bed of mixed clay occurs which is probably of Hamburg equivalence. It rests on a bed of arkose at an elevation of 116 feet above the sea level, the crystalline rocks at this point being about forty feet below; Lafayette pebbles and loams rest unconformably on its surface.

There are also mixed beds of clay of probable Hamburg equivalence in the valley of Little Lynch Creek, east of Cassatt (C. No. 783), at an elevation of approximately 360 feet M. L. T. However, it appears that the beds of Hamburg equivalence obtain to an exceedingly limited extent above the valley lines in this area.

Along an irregular line about ten miles south of the fall line the Middendorf clays are intermittently exposed from Black Creek to the Great Pee Dee River. The most northerly exposure of these clays observed is in the valley of Twitty's Prong of Bear Creek, where, at a point one and a half miles east of the Scotch Road, and at an elevation of 270 feet above the sea level, an eight-foot bed is exposed (C. No. 800). A marginal bed of rock, apparently the Eocene grit, occurs in its vicinity at the elevation of 281 feet M. L. T. Five miles southeast of this point is Sugar Loaf Mountain, which affords the following section:

Sugar Loaf Mountain, Elevation of Top 460 Feet Above Sea Level (C. No. 795).

	Thickness in feet.
Ferruginous sandstone cap	3.75
Sand, 3-16 inch, sub-angular quartz and some mica in brown matrix	9.65
White and pink micaceous sands	6.00
Coarse sub-angular sands, 1-4 inch, with pink and white clay	1.00
Undulating line of kaolin balls	.50
Yellow, red, brown and pink sands with small kaolin lenticles	3.00
Very coarse sands, 1-4 inch, encisted with purple clay and with clay bowlders at base	3.35

Coarse purple and red sands	1.10
Pink sands	7.00
White, pink and brown stratified micaceous sands	4.00
White, mealy, micaceous sands	4.80
Dark brown sands, stratified	2.60
Banded pink and white clay sands	4.00
Fine yellow, pink and salmon-colored sands	16.00
Drab clay	3.00
Sands interlaminated with clay seams	10.00
White sands, purple, coarse and harsh at bottom	15.00
Yellow, pink and salmon-colored sands	5.25
	110.00
Drab clay in pit at base	20.00

One side of this mountain, or sand knoll, has been precipitously eroded, and thus affords a suggestion as to the character of the formation of the neighboring plateaus which is largely obscured by loose sands. About two miles south of the knoll and two miles east of Middendorf a deep cut on the line of the railway from Camden to Cheraw exposes (at an elevation of 335 feet, M. L. T.) a bed of pink and drab clay 5.4 feet thick, which encloses many fossil leaves of the willow, bay, and cypress trees. This bed is exposed (C. No. 805):

	Thickness in feet.
Sands, loams and mottled clay	14.00
Unconformity.	
Medium, fine grained, pale salmon sands	1.50
Thin seams of clay interlaminated with sands, the whole undulating	2.25
Undulating, gray, cross-bedded sands, with purple lines, and with deep purple sands at base	0 to 6.00
Erosion Plane—	
Lustrous pink and drab fossiliferous clay, with surface much eroded	0 to 5.40
Coarse sands with potstone partings, and flesh and gray colored sands	2.06

Cobert Hill, which encircles the head of Juniper Creek 3½ miles south of Middendorf, exposes on its escarpment a bed of

Middendorf clay eighteen feet in thickness, separated by coarse sub-angular sands from an underlying bed about eight feet thick and purer in color (C. No. 785). The overburden on the upper bed consists of mealy, micaceous sands, yellow and red stratified sands, and red surface-clay, aggregating twenty-two feet in thickness.

From Middendorf the line of exposure of Middendorf clay extends westerly, and it can be seen in the neighboring railway cuts; it is also observed in the valley of Little Lynch Creek, 4 miles southeast of Cassatt; in beds 40 feet thick at the head of Scapo Creek (C. No. 780); and on the eastern slope of the high ridge 2½ miles north of Smithville (C. No. 775).

The plane of the Middendorf bed dipping south of east finds exposures in the railway cuts east of the Middendorf ridge, again on the hills west of Cash Station, and again at Society Hill.

The following is an analysis typical of the Middendorf clay bed of the Pee Dee Area:

Silica	55.02
Alumina	32.32
Ferric Oxide	1.23
Titanic Oxide	1.27
Lime	.16
Magnesia	.23
Soda	.56
Potash	.28
Ignition	9.27
Total	100.34

Rational Analysis:

Clay Substance	81.93
Soluble Silica	0.00
Quartz	16.24
Feldspar	2.17
Total	100.34

An upper bed of slate-colored clay, low in alumina, occurs at Society Hill at an elevation of 145 feet (C. No. 820). South of this point no beds of clay of Middendorf characteristics have been observed, but proceeding down the Great Pee Dee River depression a bed of massive black clay is found exposed at the foot of the escarpment of Floyd's Mill (east of Darlington), unconformably underlying a thick bed of stratified seams of clay with micaceous and sandy partings (E. 825). The massive black clay appears under similar materials at Mar's Bluff; and again at Burches' Ferry, its most southerly exposure, where it underlies Cretaceous marl; a sample from Floyd's Mill afforded the following analysis:

Silica	66.27
Alumina	18.03
Ferric Oxide	5.15
Titanic Oxide	1.70
Lime	.70
Magnesia	.42
Soda	.67
Potash	1.27
Ignition	6.16
Total	100.37

Rational Analysis:

Clay Substance	55.27
Soluble Silica	12.26
Quartz	27.21
Feldspar	5.63
Total	100.37

The overlying sands, laminated clays, etc., apparently beginning at Society Hill and exposed from Floyd's Mill to Louther's Lake and thence to and beyond Mar's Bluff have been regarded as Cretaceous, but we construe them as Eocene. Mar's Bluff (E. No. 845), a quarter of a mile below the ferry, is with a little hazard seen to include well up on its breast ,above the river, thin layers of characteristic fossiliferous buhr-rock, enclosed in one piece of which a bit of wood was observed. From the middle of the bluff at Louther's Lake (the old river bed) were extracted the trunk of a flattened pine tree, about ten inches in diameter, and numerous pine leaves. From Black Creek clay, near Louther's Lake, we obtained what appeared to be the trunk of a birch tree. The clay also encloses in places numerous silicified logs.

On Jeffreys' Creek near its confluence with the Pee Dee River, a Cretaceous fossiliferous green-sand marl appears, and at Burches'

Ferry the underlying black clay is observed gradually emerging from the Pee Dee River, with a northerly dip (C. No. 855). On the adjacent ridge the marl rises above the river forty feet, and the Eocene is reduced to a thin bed of stratified white sands and slabs of fossiliferous buhr-rock (E. No. 872). It was in such rock, near this point, that Mr. Tuomey found Turritella Mortoni and Venericardia Planicosta, characteristic Eocene shells. South of this point the black clay is not again observed; but the Cretaceous marl forms a trough, whose width extends almost to Allison's Landing (C. No. 870), above the confluence of Lynch River. The upper portion of the trough, with the Cretaceous marl about nine feet above the low river mark, supports beds of Eocene sands and clay seams aggregating forty-one feet in thickness; the southerly portion is filled with compact Tertiary marls to a depth extending below the river level. These Tertiary marls are intermittently exposed along a zone extending below Effingham (E. No. 885) and as far west as Mayesville (E. No. 800). At Davis Landing (C. No. 867) Cretaceous greensand marl again emerges, to a height of sixteen feet, supporting twenty-one feet of Tertiary marls. South of Davis Landing the Tertiary marl appears at Savage Landing, beyond which it fades out. From Allison's Landing to Topsaw Landing (C. No. 880) the greensand marl extends intermittently exposed, and affords an average decline of elevation of less than a foot to the mile. This marl is also exposed on Lynch River above Effingham (C. No. 885), on the Little Pee Dee east of Mullins (C. No. 915), and on the Waccamaw River from near the North Carolina line to a point near Conway (C. No. 855). In many places it affords material suited for the manufacture of a good paving brick. The drab clays exposed along Black Creek and Black River also have good susceptibilities for brick making.

In addition to the above cited Cretaceous and Eocene clays in the Pee Dee Area, extensive beds of superior brick clays of very late Tertiary equivalence extend along the valleys of certain streams; notably those east of the Great Pee Dee River—Cat Fish Creek, the Upper Waccamaw; they also occur at Mandeville and in places on Jeffreys' Creek. The alluvial clays usually occur in valuable deposits where the large streams first expand after leaving the crystalline region—in the Pee Dee Area they are found at Society Hill. Thin beds of alluvial clay in the swamps of the Pee Dee River below its confluence with Lynch River afford moderately good brick material.

CHAPTER IX.

PHYSICAL AND CHEMICAL PROPERTIES OF SOUTH CAROLINA CLAYS.

DESCRIPTIVE.

In the descriptions of the individual properties on which clays occur, as either well defined deposits or as uncertain prospects, the following principles have been observed:

SURVEY NUMBERS.

Each geological exposure is given a survey number, affixed to the initial letter of the relating geologic period—thus the letter "C" relates to Cretaceous, the letter "E" to Eocene, the letter "N" to Neocene, the letter "M" to Miocene, the letter "P" to Pliocene, and the letter "R" to Recent exposures; the letters "X" and "Y" apply to exposures of unidentified horizons.

THE AIKEN OR SAVANNAH RIVER AREA comprises numbers from	0 to 250
THE EDISTO AREA comprises numbers from	250 to 500
THE SANTEE AREA comprises numbers from	500 to 750
THE PEE DEE AREA comprises numbers from	750 to 1000

SUB-AREAS.

The lesser streams draining the respective deposits afford names for the sub-areas; other distinctive names are applied to the latter in those cases where deposits occur immediately contiguous to the greater streams.

DISTANCES.

The distances indicated are approximate and along air lines.

LOCATION.

Localities are indicated by the distance, and the approximate aximuth of an air line, from the nearest point of transportation.

DRAINAGE SUSCEPTIBILITIES.

Where the development of a clay body would admit of the discharge of the associate water through ditches or flumes the term *"Gravity"* is used, and in cases where pumping devices would be

necessary the term *"Power"* is applied to the character of the drainage.

PHYSICAL PROPERTIES.

The effects of these conditions have been explained in Chapter IV, except as relates to the expression of hardness, which is in accordance with the standard mineral scale.

CHEMICAL PROPERTIES.

The behavior of the various and varying constituents of clays separately and jointly exposed to heat, and in other circumstances, has been treated in Chapter IV.

PYROMETRIC FEATURES.

For the furnace tests record is given of those features determined by the temperatures ordinarily attained in the Ceramic Arts, 1210 degrees C. (2210 degrees F.) and 1350 degrees C. (2462 degrees F.). The former indicates the limit of fusion of the more fusible components admitted in the manufacture of the ordinary wares, the latter temperature ensures the fusion of the feldspathic constituent which affects the availability of clays for the manufacture of the better wares.

Whereas the fusion point of the test glaze applied is 1100 degrees C. (2012 degrees F.) the heat to which it has been subjected on the wares attained the respective temperatures of 1210 degrees C. and 1350 degrees C., the latter ensuring the development of refractory coloring matter, excepting titanium which may be disregarded.

The tests recorded represent the respective clays in their natural condition, without the addition of the oxide of Cobalt or other correctives.

SAMPLES.

The selection of samples for analysis has principally been so directed as to afford information as to the physical and chemical properties of clays occurring in quantities of industrial importance. In the case of immediately contiguous beds the analysis of the type is indicated as very approximately applying to its associates, closely concurring physical and pyrometric results of tests indicating such similarity.

Some of the localities indicated in this chapter afford clay in uncertain quantities, but are of such promise as should warrant the owners in sinking test pits. In many instances a thick seam of water-bearing sand, overlying the clay-bed, prevents the successful use of the sampling auger, unless test pits are first sunk to the surface of the clay.

A surface of clay long exposed to the weather undergoes alterations, which render samples from such exposures unreliable for chemical, physical and pyrometric tests, by which to appraise the main body of the associate clay.

AIKEN AREA.

LOWER HAMBURG CLAYS.

The lower Hamburg clays in the Aiken Area occur at exposures C. No. 5, No. 10, No. 14, No. 15, and No. 20. Their high colors have discouraged their industrial development.

The following features relating to a sample from C. No. 5 may be regarded as typical of these clays:

SURVEY NUMBER OF EXPOSURE C. NO. 5.

Aiken Area—

Location—Alongside Columbia-Augusta Railway (98.5 M. P.); 2.5 miles east of Hamburg (railway station); connected by road; 0.5 miles distant from a bold branch of clear freestone water.

Geognosy—Overburden: 44 feet with gradual increase. Thickness of clay: 7 feet, white; 4 feet, white and red laminated.

Drainage—gravity.

Physical properties—Texture: Partly fine grained, partly gritty. Color: Average, deep pink, dry; deeper pink, wet. Specific Gravity: 2.5. Plasticity: Good (27.1 per cent.). Tensile Strength: 5 to 7 pounds. Slakes: Readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	7.25	26.9	1.5	Pink	
1350 degrees C.	18.35	15.1	3.0	Dirty.	Yellow.

do. moderately compact body.

Remarks: Two railway tracks, between the scarp on which clay occurs and the low ground required for waste pile, would embarrass development if otherwise desirable.

UPPER HAMBURG CLAYS.

The Upper Hamburg Clay zone of the Aiken Area contributes exceeding 20,000 tons of sedimentary kaolin to the market each year. It is prominently developed at exposures C. No. 100, No. 105, No. 110, and also at C. No. 114, No. 120, and No. 125, and possibly at the base of C. No. 205. The character of C. No. 100 may be regarded as representing also C. No. 105 and C. No. 110. The other exposures are greatly obscured.

SURVEY NUMBER OF EXPOSURE C NO. 100.

Aiken Area—Horse Creek Sub-Area—

Location: McNamee & Co. place, 1.25 miles southeast of Bath (railway station); connected by spur track with Bath; 1.25 miles distant from Horse Creek, a stream of clear freestone water.

Geognosy—Overburden: 0 to 60 feet. Thickness of clay: 5 to 15 feet. Drainage: Gravity.

Physical Properties—Texture: Very fine grained and free from grit.

Color: White, dry; pale cream, wet. (Parts of bed slightly discolored.)

Specific Gravity: 2.5.

Plasticity: Good (30.30 per cent water).

Tensile Strength: 9 to 13 pounds.

Slakes: Readily.

Under Microscope: Amorphous, translucent, some particles of amber color, no opaque matter.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1050 degrees C.	10.25	26	2.5	White	
1150 degrees C.	10.25	24	3.0	White	
1250 degrees C.	14.50	19	3.5	White	
1350 degrees C.	16.00	8	4.0	White	White

Chemical Analysis:

Silica.	45.02
Alumina.	38.98
Ferric Oxide.	.77

Titanic Oxide	.85
Lime	.03
Magnesia	.07
Soda	.55
Potash	.26
Ignition	13.58
Total	100.11

Rational analysis:

Clay Substance	96.95
Quartz	2.00
Feldspar	1.16
Total	100.11

Remarks—This clay requires no other preparation than simply air drying. It is excellently adapted to both paper stock and china ware manufacture. It produces a very white biscuit of fine texture, without checking, and takes glaze without developing color. The deposit is extensive and the equipment admits of handling 15,000 tons a year. This clay affords 2,300 to 2,400 pounds of dry clay to the cubic yard, in situ, the density increasing with the amount of the overburden. It produces biscuit of very white and fine body, but requires the addition of a clay of greater tensile strength to insure safe handling of the air dried ware.

SURVEY NUMBER OF EXPOSURE C. NO. 105.

Aiken Area—Horse Creek Sub-area—T. G. Lamar Co., Kaolin Mine.

1.3 miles N. E. from Langley (railway station); connected by spur track; 1.3 miles distant from Horse Creek, a stream of clear freestone water.

Thickness of bed: 5 to 15 feet. Thickness of overburden: 0 to 50 feet. Capacity 10,000 tons per annum.

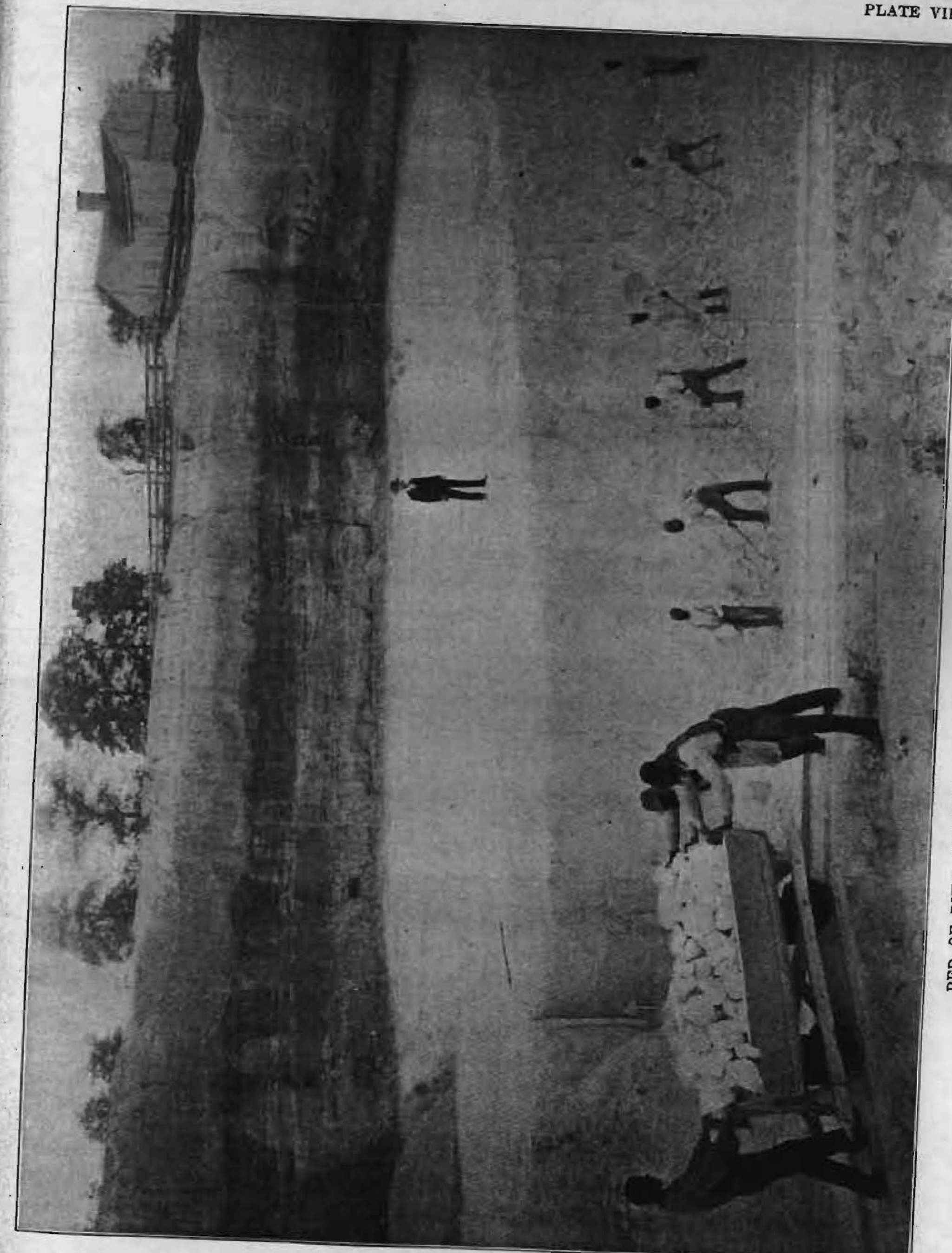
Physical and chemical features similar to those of C. No. 100.

SURVEY NUMBER OF EXPOSURE C. NO. 110.

Aiken Area—Horse Creek Sub-area—Paragon Kaolin Works.

1.5 miles N. E. from Langley (railway station); connected by spur track; 1.5 miles distant from Horse Creek, a stream of clear freestone water.

PLATE VII.



BED OF PURE SEDIMENTARY KAOLIN EIGHTEEN FEET THICK—AIKEN AREA.

Thickness of bed: 5 to 15 feet. Thickness of overburden: 0 to 50 feet. Capacity 10,000 tons per annum.

Physical and chemical features similar to those of C. No. 100.

SURVEY NUMBER OF EXPOSURE C. 120.

Aiken Area; Hasell (R.). 2.25 miles north from Beech Island (railway station), connected by public road; 0.0 miles distant from branch of clear freestone water. Exposed in bed of branch.

Physical—Texture: fine grained. Color: grayish white. Under the miscroscope scales of muscovite appear.

Pyrometric—Under fire it develops a compact body with cream white color, which is slightly heightened by glaze.

Remarks—This clay deposit should commend itself to investigation by the owner.

SURVEY NUMBER OF EXPOSURE C. NO. 125.

Aiken Area, Town Creek Sub-area; Ramsey (G. T.); 3.5 miles N. E. from Kathwood (railway station); connected by public road; 0.2 miles distant from Town Creek, a stream of clear freestone water. Partial exposures at several points, along scarp on south of Town Creek near confluence with Hollow Creek.

MIDDENDORF CLAY ZONE.

Occurs at exposures C. No. 145, No. 150,, No. 155, No. 160, No. 165, No. 167, No. 169, No. 170, No. 173, No. 175, No. 180, No. 181, No. 190, No. 195, No. 200, No. 205 and No. 210.

Mined at C. No. 150, No. 155, No. 165, No. 195 and No. 205.

Formerly mined at C. No. 145 and No. 160.

SURVEY NUMBER OF EXPOSURE C. NO. 145.

Aiken Area, Beech Island Sub-area; Davies (Col. T. J. Estate); 1.4 miles distant from Beech Island (railway station); connected by public road; 0.3 miles distant from a small branch of clear freestone water. Thickness of bed 5 to 6 feet. Thickness of overburden 0 to 25 feet, and increasing; once extensively worked, now abandoned.

Physical Properties—Texture: fine grained. Color: lustrous white. The microscope reveals no opaque minerals.

Pyrometric—At 1350 degrees C.: affords good body with a hardness of 3.5 and a slightly creamy white color.

SURVEY NUMBER OF EXPOSURE C. NO. 150.

Aiken Area—Town Creek Sub-area—Immaculate Kaolin Co.

Location: 2 miles S. E. from Langley (railway station); connected by spur track with Langley; 2.0 miles distant from Horse Creek, a clear stream of freestone water.

Geognosy—Overburden 0 to 40 feet. Thickness of clay 15 to 25 feet. Drainage: gravity, good.

Physical Properties—Texture: Fine grained. Color: Upper portion pale drab; lower portion very white and in places purple. Specific gravity: 2.50. Plasticity: good, 34.2 per cent. Tensile strength: 18 to 36 pounds. Slakes: readily to gray and cream color. Under the microsocpe: Translucent, amorphous, white, with some colored particles and a few acicular crystals.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	13.2	24.2	2.5	White	
1350 degrees C.	22.5	4.5	4.0	White	Light cream

1350 degrees C. Compact body with very slight checking.

Chemical analysis:

Silica	44.23
Alumina	38.92
Ferric Oxide	2.31
Titanic Oxide	1.21
Lime	.12
Magnesia	Trace.
Soda	.26
Potash	.30
Ignition	12.90
Total	100.25

Rational Analysis:

Clay Substance	99.29
Quartz	.49
Feldspar	.47
Total	100.25

Remarks—The lower portion of this bed is very white, and superior in quality to the upper portion, but both are in demand. This property is equipped to handle about 10,000 tons each year. It affords a good paper stock clay and although its shrinkage is a little high it is well adapted to the potter's use.

SURVEY NUMBER OF EXPOSURE C. NO. 155.

Aiken Area—Horse Creek Sub-area—Peerless Clay Co.

Location—1.9 miles S. E. from Langley (railway station); connected by spur track with Langley, 1.9 miles distant from Horse Creek, a clear stream of freestone water.

Geognosy—Overburden 0 to 40 feet. Thickness of clay 15 to 25 feet. Drainage: Gravity, good.

Physical Properties—Texture: Fine grained. Color: Upper portion pale drab; lower portion very white and in places purple. Specific gravity: 2.50. Plasticity: good, 34.2 per cent. Tensile Strength: 8 to 16 pounds. Slakes: readily to gray and cream color.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	15.00	20.0			
1350 degrees C.	23.00	4.4	4.0	Lt.-cream	Cream

1350 degrees C., compact body with very slight checking.

Chemical analysis:

Silica	44.66
Alumina	37.90
Ferric Oxide	2.53
Titanic Oxide	1.29
Lime	.08
Magnesia	Trace.
Soda	.41
Potash	.36
Ignition	13.17
Total	100.40

Rational analysis:

Clay Substance	99.60
Quartz	.16
Feldspar	.64
Total	100.40

Remarks—The upper portion of this deposit of clay is somewhat stained with ferruginous matter; the lower portion represented by the above analysis is a superior white clay.

This property is equipped to handle about 10,000 tons of clay each year. This clay is well suited not only to the uses of the paper makers, but for diverse mixtures in the potter's art.

SURVEY NUMBER OF EXPOSURE C. NO. 160.

Aiken Area, Town Creek Sub-area; Allen place; 4.0 miles S. E. from Langley (railway station); connected by public road; 1.7 miles distant from the northerly tributary of Town Creek. Thickness of bed, 9 feet; thickness of overburden, 0 feet to 30 feet; erosion has greatly interrupted continuity. This deposit was at one time worked to a limited extent.

SURVEY NUMBER OF EXPOSURE C. NO. 163.

Aiken Area, Town Creek Sub-area; Ford (J. M.); 3.0 miles south of Warrenville (railway station); connected by road; 0.3 mile distant from branch of Town Creek. Thickness of bed, from 9 to 30 feet (information); thickness of overburden, 9 to 30 feet; exposure highly obscured; no development; water-bearing sand overlies this clay.

SURVEY NUMBER OF EXPOSURE C. NO. 165.

Aiken Area, Town Creek Sub-area; Sterling Kaolin Co.; 3.25 miles south of Warrenville (railway station); connected by road; 0.5 miles distant from branch of Town Creek. Thickness of bed: 8 feet exposed, said to extend to 32 feet; thickness of overburden: 0 to 25 feet. Equipped with a small dry shed.

Physical properties—Texture: Fine grained. Color: White and purple.

Pyrometric—At 1350 degrees C.; develops a compact body with a hardness of 3.5 and a cream white color, slightly increased by glazing.

SURVEY NUMBER OF EXPOSURE C. NO. 167.

Aiken Area, Wise Creek Sub-area; Harrigal (J. G.); 1.5 miles south from Warrenville (railway station); connected by road; 1.0 miles distant from Wise Creek. Thickness of bed: 0 to 20 feet (information); thickness of overburden: 0 to 14 feet, with gradual increase.

Physical Properties—Texture: Fine grained. Color: Lustrous white. Plasticity: good. Tensile strength: 25 to 30 pounds.

Pyrometric—At 1350 degrees C.: develops a dense body with a hardness of 3.5 and a cream white color heightened slightly by glaze. Shrinkage: 16 per cent.

SURVEY NUMBER OF EXPOSURE C. NO. 169.

Aiken Area, Wise Creek Sub-area; Whitney (W. C.) place; 2.25 miles S. E. from Warrenville (railway station); connected by road; 0.0 miles distant from bold freestone spring. Thickness of bed: 10 feet exposed; thickness of overburden: 30 feet, with gradual increase.

Physical properties—Texture: Mixed. Color: Lustrous white, in part iron stained. Plasticity: Good. Tensile Strength: 26 to 34 pounds.

Pyrometric—At 1350 degrees C.; develops a dense body becoming yellow under glaze. Shrinkage: 25 per cent.

SURVEY NUMBER OF EXPOSURE C. NO. 170.

Aiken Area, Wise Creek Sub-area; Hitchcock place; 3.0 miles east from Warrenville (railway station); connected by road; 0.5 miles distant from Wise Creek. Thickness of bed: 12 feet (exposed); thickness of overburden: 18 feet, with gradual increase.

Physical Features—Texture: Gritty. Color: Lustrous white with some iron stain. Plasticity: Good. Tensile strength: 8 to 12 pounds.

Pyrometric—At 1350 degrees C.: Develops dense smooth grayish white body with a hardness of 4.0. Glaze color: Yellow. Shrinkage 22 per cent.

SURVEY NUMBER OF EXPOSURE C. NO. 173.

Aiken Area, Wise Creek Sub-area; 0.5 miles distant from Aiken (railway station); connected by public road; opposite side of road to Coker Spring, and within the municipal limits. Similar in character to C. No. 175.

SURVEY NUMBER OF EXPOSURE C. NO. 175.

Aiken Area, Wise Creek Sub-area. Location: Richards' place, alongside railway, 1 mile west of freight depot.

Geognosy—Overburden: 0 to 25 feet. Thickness of clay: 14 feet exposed. Drainage in part by gravity.

Physical Properties—Texture: Very fine grained. Color: White with pale yellow green cast and waxy lustre, some iron stains. Specific gravity: 2.25. Plasticity: Good (29.4 per cent.). Tensile strength: 7 to 9 pounds. Slakes: Gradually.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1250 degrees C.	6.55	22.30	2.5	Pink	
1350 degrees C.	18.75	2.70	4.0	Gray	Lt.-Yellow

1350 degrees C., incipient vitrification.

Chemical analysis:

Silica	47.49
Alumina	35.56
Ferric Oxide	2.47
Titanic Oxide	.94
Lime	Trace.
Magnesia	Trace.
Soda	.74
Potash	.13
Ignition	12.86
Total	100.19

Rational analysis:

Clay Substance	96.43
Quartz	2.27
Feldspar	1.49
Total	100.19

Remarks—This deposit affords a large body of clay but the right of way with the embankment of the Charleston-Augusta Railway covers the best part of the bed. Well adapted to the manufacture of ornamental tiles and brick.

SURVEY NUMBER OF EXPOSURE C. NO. 180 AND NO. 181.

Aiken Area—Wise Creek Sub-area—Sharpton (Mrs. George).

Location—1 mile N. E. from Warrenville (railway station); connected by road (0.3 miles from railway); 0.5 miles from Wise Creek.

Geognosy—Overburden 10 to 40 feet. Thickness of clay: upper layer 3 to 18 feet; interlaminated sands: 12 feet; lower layer: 12 to 15 feet. Drainage: gravity.

Physical Properties—Texture: gritty. Color: lustrous greenish white, with some iron stains. Specific gravity: 2.40. Plasticity: good (28 per cent.). Tensile strength: 36 to 53 pounds, 20 to 29.5 pounds. Slakes: gradually. Under miscroscope: a few scattered fine particles of hornblende.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
Upper part—					
1350 degrees C.	22.00	4.5	4.0	Sub-White	Yellow Gray
Lower part—					
1350 degrees C.	26.00	3.00	4.0	Sub-White	Yellow Gray

Chemical analysis (upper and lower):

Silica	50.87	55.61
Alumina	31.49	27.44
Ferric Oxide	2.44	1.60
Titanic Oxide	1.20	1.82
Lime	.32	.14
Magnesia	.25	.19
Soda	1.01	2.51
Potash	.63	.33
Ignition	11.42	10.39
Total	99.63	100.03

Rational analysis:

No. 180, upper part—

Clay Substance	86.23
Quartz	10.93
Feldspar	2.47
Total	99.63

No. 181, lower part—

Clay Substance	76.25
Quartz	20.60
Feldspar	3.18
Total	100.03

Remarks—This deposit is quite extensive. Its excessive content of grit would exact washing to secure admission to the market.

SURVEY NUMBER OF EXPOSURE C. NO. 185.

Aiken Area, Bridge Creek Sub-area; Graniteville Mfg. Co.; 1.2 miles N. E. from Graniteville (railway station); connected by road; 0.5 miles distant from Bridge Creek, a stream of clear freestone water. This bed is an extension of and similar to the Sharpton bed, C. No. 180 and No. 181, but the overburden represents Sharpton maximum 40 feet.

SURVEY NUMBER OF EXPOSURE C. NO 190.

Aiken Area, Bridge Creek Sub-area; Wise (Mrs. C. B.); 3.2 miles N. E. from Graniteville (railway station); connected by public road; 0.1 miles distant from southern tributary of Bridge Creek. Thickness of beds: 18 feet, of mixed character. Thickness of overburden: 7 feet, with rapid increase.

SURVEY NUMBER OF EXPOSURE C. NO. 195.

Aiken Area, Bridge Creek Sub-area; McMillan (J. B.). Location: 3.50 miles N. W. from Aiken; (railway station); connected by road; on both sides of China Spring Branch (with bold flow of clear freestone water).

Geognosy—Overburden: in narrow valley 12 feet, rapid increase on hillside. Thickness of clay: 13 to 26 feet. Drainage: upper portion gravity; lower portion by power.

Physical Properties—Texture: Upper portion fine grained; intermediate portion, micaceous; lower portion, fine grained. Color: purple and white. Specific gravity: 2.4. Plasticity: good (26.1 per cent.). Tensile strength: 6 to 7 pounds. Slakes: well.

Under the microscope this clay appears white, amorphous and translucent. No opaque impurities. The seam of intermediate "ruggage" affords scales of muscovite.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.		26.0	3		
1350 degrees C.		19.5	4	White	White

Chemical analysis:

Silica	44.51
Alumina	38.12
Ferric Oxide	1.75
Titanic Oxide	1.11
Lime	.06
Magnesia	Trace.
Soda	.41
Potash	.32
Ignition	13.45
Total	99.73

Rational Analysis:

Clay Substance	98.19
Quartz	1.06
Feldspar	.48
Total	99.73

Remarks—This extensive body of clay probably represents a layer of the upper Hamburg clay with a layer of the Middendorf immediately superimposed, and a micaceous clay intervening.

The analysis relates to the lower portion. It affords, without the addition of other clays, good faience ware from a mixture incorporating nine parts of this clay, six parts of "flint" and three parts of "spar."

The upper portion affords a very superior grade of ornamental light-colored brick and tiling.

SURVEY NUMBER OF EXPOSURE C. NO. 200.

Aiken Area, Horse Creek Sub-area; Green (Walker); 2.6 miles west from Miles' Mill (railway station); connected by road; 0.5 miles distant from head of Horse Creek. Thickness of bed: 4 feet; overburden: 5 feet with rapid increase. Clay properties: fine grained, pink color (many fossil leaves present). Tensile strength: 20 to 24 pounds. At 1350 degrees C.: color pink. Shrinkage: 14.75 per cent. Water absorption: 9.2. Hardness: 4.0.

SURVEY NUMBER OF EXPOSURE C. NO. 205.

Aiken Area—Horse Creek Sub-area—
Sterling Kaolin Co.

Location—1.5 miles west from Graniteville (railway station); connected by road; 1.5 miles distant from Horse Creek, a stream of clear freestone water.

Geognosy—Overburden: 27 feet. Thickness of clay: 8 to 12 feet. Drainage: Gravity and power.

*Chemical Analysis:**

Silica	43.18
Alumina	37.36
Ferric Oxide	0.91
Magnesia	0.5
Potash	2.00
Ignition	14.32
Total	98.27

Remarks—This deposit is provided with an equipment to handle about 7,000 tons of clay each year. It has found much favor as a paper stock clay.

*Furnished by proprietor.

SURVEY NUMBER OF EXPOSURE C. NO. 210.

Aiken Area—Horse Creek Sub-area—
Langley Manufacturing Co.

Location: 1.5 miles north of Langley (railway station) connected by road; 0.6 miles distant from Horse Creek.

Geognosy—Overburden 0 to 30 feet. Thickness of clay: 0 to 15 feet, in marginal patches. Drainage: gravity.

Physical properties—Texture: Fine grained. Color: Lustrous pink and sub-white. Specific gravity: 2.5. Plasticity: good (27.6), Tensile Strength: 11 to 15 pounds. Slakes: readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	11.5	12.0			
1350 degrees C.	12.9	11.0	4	C-White	Cream

Chemical analysis:

Silica	45.07
Alumina	35.61
Ferric Oxide	2.21
Titanic Oxide	1.56
Lime	.16
Magnesia	.25
Soda	1.37
Potash	1.10
Ignition	12.39
Total	99.72

Rational Analysis:

Clay Substance	90.62
Quartz	3.52
Feldspar	5.58
Total	99.72

Remarks—This deposit of clay is apparently of limited extent, being along the littoral line of the Middendorf bed. It encloses many fossil leaves.

SURVEY NUMBER OF EXPOSURE P. NO. 10.

Savannah River Area—Garnett Sub-area—

Location: 2.5 miles N. E. from Garnett (railway station); 0.75 miles E. of Denmark-Savannah Railroad.

Geognosy—Overburden: 1.5 to 3 feet of sand, and some arenaceous clay. Thickness of clay: Maximum 11 feet with gradual decrease towards margin of basin. Drainage: Power.

Physical Properties—Texture: Fine grained to gritty. Color: White, yellow and bluish gray. Specific gravity: 2.5. Plasticity: Good. Tensile Strength: 60 to 64 pounds, Slakes: slowly.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1150 degrees C.	9.3	12.0	2.5	Red	
1250 degrees C.	12.0	7.1	3.5	Red	Brown
Smooth body.					Pink

Chemical analysis:

Silica	64.22
Alumina	20.15
Ferric Oxide	5.22
Titanic Oxide	.81
Lime	.32
Magnesia	.14
Soda	1.08
Potash	1.08
Ignition	7.36
Total	100.38

Rational Analysis:

Clay Substance	54.26
Quartz	38.98
Feldspar	7.14
Total	100.38

Remarks—This bed of clay occupies one of a series of basins, the deposit decreasing in thickness towards the margin.

The clay is excellently adapted to the manufacture of face-brick and tiling. Without the exercise of great care in the drying process some sand should be incorporated. The detailed features of this clay are given as typical of this class of deposits found along a zone parallel to the coast line, and probably pertaining to the Pliocene formation.

SURVEY NUMBER OF EXPOSURE Y. NO. 10.

Aiken Area, North Augusta Sub-area. Location: at foot of hill opposite the North Augusta Bridge.

Chemical analysis:

Silica	75.20
Alumina	15.45
Ferric Oxide	1.79
Titanic Oxide	.56
Lime	.34
Magnesia	.22
Soda	.27
Potash	.96
Ignition	5.23
Total	100.02

Rational Analysis:

Clay Substance	42.61
Quartz	54.65
Feldspar	2.76
Total	100.02

Remarks—This meta-residual clay represents an extensive bed of altered shales, which, at other points in this area, are higher in clay substance and lower in iron, notably near the old Landrum Pottery.

SURVEY NUMBER OF EXPOSURE X. NO. 55.

Savannah River Area, Abbeville Sub-area.

Location: 1 mile south of Abbeville Courthouse, on Wilson place.

Geognosy—Overburden: About 20 feet. Thickness of clay: Not exposed. Drainage: Power.

Physical properties—Texture: Fine grained to slightly micaceous. Color: Sub white. Specific gravity: 2.5. Plasticity: Good. Tensile strength: 28 to 42. Slakes: Readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	12.00	13.8	3.0		
1350 degrees C.	15.00	10.7	3.5	Cream	Cream

1350 degrees C. smooth, compact body.

Chemical analysis:

Silica	72.81
Alumina	14.90
Ferric Oxide	1.93
Lime	.56
Magnesia	.36
Soda	3.21
Potash	4.16
Ignition	1.99
Total	99.92

Rational analysis:

Clay Substance	19.65
Quartz	33.17
Feldspar	47.10
Total	99.92

Remarks—The sample affording the above analysis was taken from a well. The material appears to be a decomposing oligoclase granulyte. The quantity is obscured, but if abundant this material should afford an excellent clay to bond more refractory clays in the manufacture of the faience wares. The above tests result from a sample freed from grit.

SURVEY NUMBER OF EXPOSURE X. NO 160.

Savannah River Area.

Location: Near Edgefield Courthouse, Dr. Parker's place.

Physical properties—Texture: Fine grained to gritty. Color: Mauve. Specific gravity: 1.5. Plasticity: Good. Tensile strength: 60 to 70 pounds. Slakes: Fairly.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1250 degrees C.	17.0	3.75	4	B. red	

Chemical analysis:

Silica	52.41
Alumina	21.14
Ferric Oxide	12.02
Titanic Oxide	1.47
Lime	1.04
Magnesia	.56
Soda	1.12
Potash	.95
Ignition	8.95
Total	99.66

Rational analysis:

Clay Substance	60.08
Quartz	21.12
Feldspar	10.46
Total	99.66

Remarks—This clay is extensively used in mixtures for the manufacture of stone ware, etc.

(This deposit has not yet come under the immediate inspection of the Survey.)

EDISTO AREA.

SURVEY NUMBER OF EXPOSURE C. NO. 255.

Courtney (E. M.); 12 miles N. E. from Aiken (railway station); connected by public road; 0.6 miles distant from Edisto River. Thickness of bed: 4 feet to 12 feet; thickness of overburden: rapid increase above 1 foot.

SURVEY NUMBER OF EXPOSURE C. NO. 260.

Edisto Area, Rocky Creek Sub-area; Brodie (J.).

Location: 12 miles N. E. of Aiken (railway station); connected by public road; 0.4 miles distant from Rocky Creek.

Geognosy—Overburden: 22 feet. Thickness of Clay: 0 to 20 feet in patches. Drainage: Would require power.

Physical properties—Texture: Fine grained. Color: White. Specific gravity: 2.5. Plasticity: Good. Tensile strength: 4 to 8 pounds. Slakes: Readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	7.5	23.2	2.0		
1350 degrees C.	13.0	19.2	3.5	Cr. w.	Cream

1350 degrees C. compact body.

Chemical analysis:

Silica	44.11
Alumina	38.19
Ferric Oxide	1.55
Titanic Oxide	1.30
Lime	.14
Magnesia	Trace.
Soda	.53
Potash	.50
Ignition	13.37
Total	99.69

Rational analysis:

Clay Substance	98.77
Quartz	.22
Feldspar	.70
Total	99.69

Remarks—With improved transportation facilities this clay upon being washed should find ready admission to the market.

SURVEY NUMBER OF EXPOSURE C. NO. 268.

Edisto Area, South Edisto Sub-area; (Quattlebaum estate); 13 miles northeast from Aiken (railway station); connected by public road. Thickness of bed: 10.3 feet of buff and mixed clay; thickness of overburden: 0 to 30 feet.

SURVEY NUMBER OF EXPOSURE C. NO. 270.

Aiken Area, Rocky Creek Sub-area; Reddy (J.); 5 miles west from Seivern; (railway station); connected by public road; 1 mile distant from Rocky Creek. Thickness of bed: 7 feet; thickness of overburden: 0 feet to 15 feet.

SURVEY NUMBER OF EXPOSURE C. NO. 275.

Edisto Area—Lightwood Creek Sub-area; (Keesler place.).

Location: 3.0 miles southest of Leesville (railway station); connected by road.

Geognosy—Overburden: 12 feet of rock. Thickness of clay: 10 feet exposed. Drainage: Gravity.

Physical properties—Texture: Medium fine to slightly gritty. Color: Cream white. Specific Gravity: 2.5. Plasticity: Fair: Tensile Strength: 12 to 14 pounds. Slakes: Fairly well.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	3.5	25.0	2.5	Yel.-White	Yellow
1350 degrees C.	9.0	3.5	2.5	Yel.-White	Yellow

Chemical analysis:

Silica	60.21
Alumina	26.62
Ferric Oxide	1.89
Titanic Oxide	.91
Lime	.19
Magnesia	.24
Soda	.97
Potash	.67
Ignition	8.58
Total	100.28

Rational analysis:

Clay Substance	67.56
Quartz	28.74
Feldspar	3.98
Total	100.28

Remarks—Erosion has left this clay in isolated patches.

SURVEY NUMBER OF EXPOSURE C. NO. 280.

Edisto Area—Lightwood Creek Sub-area—Railroad right of way; 1.5 miles south from Westland (railway station), connected by road. Thickness of bed: 12 feet, exposed. Thickness of overburden: 11 feet with rapid increase. Texture: Fine grained to gritty. Color: Deep purple, with some iron stain.

SURVEY NUMBER OF EXPOSURE C. NO. 295.

Edisto Area—Chalk Hill Sub-area—Trenholm (W. L. Estate).

Location—3.7 miles west of Seivern (railway station); connected by road; 0.5 miles from Chalk Hill Creek.

Geognosy—Overburden: 0 to very heavy. Thickness of clay: 0 to 21 feet. Drainage: Part gravity; part power.

Physical properties—Texture: Very fine grained. Color: Pure white. Specific Gravity: 2.5. Plasticity: Good (26.7 per cent.). Tensile Strength: 17 to 24 pounds. Slakes: Readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	13	27.73	2.5	White	
1350 degrees C.	20	2.00	4	White	White

Chemical analysis:

Silica	46.99
Alumina	36.08
Ferric Oxide	1.02
Titanic Oxide	.86
Lime	Trace.

Magnesia	Trace.
Soda	1.09
Potash	.20
Ignition	13.82
Total	100.06

Rational analysis:

Clay Substance	88.99
Quartz	4.53
Feldspar	6.54
Total	100.06

Remarks—This is a very superior clay for the manufacture of porcelain ware. It is observed along a scarp near the northwestern corner of this property. Along Chalk Hill Creek a lower bed of clay is observed, but it is of less attractive character. The upper bed of clay extends under the Hutto property, C. No. 294, and the Man Gant property, C. No. 296, with a very heavy overburden.

SURVEY NUMBER OF EXPOSURE C. NO. 300.

Edisto Area—Juniper Creek Sub-area—Imperial Kaolin Co..

Location: At Seivern (railway station), connected by spur track. On Creek.

Geognosy—Overburden: 0 to 40 feet. Thickness of clay: 0 to 35 feet. Drainage: Part gravity, part power.

Physical properties—Texture: Part fine grained; part gritty; requires washing. Color: White, pink, purple and yellow. Specific Gravity: 2.5. Plasticity: Good (30.4 per cent.). Tensile Strength: 15 to 18 pounds. Slakes: Readily. Local occurrences of iron pyrites.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	15.0	15	3	Cream	
1350 degrees C.	21.0	11	4	Cream	Cream

Chemical analysis:

Silica	45.69
Alumina	37.47
Ferric Oxide	1.01
Titanic Oxide	1.44
Lime	Trace.
Soda	.69
Potash	.08
Ignition	13.98
Total	100.36

Rational analysis:

Clay Substance	94.68
Quartz	3.76
Feldspar	1.92
Total	100.36

Remarks—This plant is equipped with a plant for washing 15 tons of clay each day. The deposit is extensive. This clay is admitted to the manufacture of sanitary wares. It is well suited to the manufacture of refractory crucibles.

SURVEY NUMBER OF EXPOSURE C. NO. 305.

Edisto Area—Gunter's Branch Sub-area—Marshall Gunter.

3.0 miles east from Seivern (railway station), connected by road. Exposed along bold branch. Thickness of bed: 5 feet, exposed. Thickness of overburden: 15 feet, with rapid increase.

SURVEY NUMBER OF EXPOSURE C. NO. 315.

Edisto Area—Hood's Branch Sub-area—Fallaw (B.).

Location: 6 miles east of Seivern (railway station), connected by road. Along Hood's Branch.

Geognosy—Overburden: 5 feet, with gradual increase. Thickness of clay: 3 to 9 feet. Drainage: Would require power.

Physical properties—Texture: Fine grained. Color: White and dark gray (organic coloring), some iron stain. Specific Gravity: 3.0. Plasticity: Good (26.0 per cent.). Tensile Strength: 12 to 20 pounds. Slakes: Readily to light gray color. Under Microsope: No opaque foreign matter.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	10.3	28.0	2	White	White
1350 degrees C.	15.0	8.9	4	White	Lt.-C'm

1350 degrees C. . . . . Body with smooth fine texture and very slight checking.

Chemical analysis:

Silica	45.10
Alumina	38.69
Ferric Oxide	1.28
Titanic Oxide	1.00
Lime	.02
Magnesia	.03
Soda	.52
Potash	.37
Ignition	13.52
Total	100.53

Rational analysis:

Clay Substance	96.89
Quartz	2.48
Feldspar	1.16
Total	100.53

Remarks—This clay deposit extends under portions of this and the adjoining properties; with improved transportation facilities it could be profitably developed.

It is well adapted to the manufacture of the faience wares and constitutes good paper stock clay. To be utilized to the best advantage, this clay should be washed, under which conditions the greater portion of the deposit would approximate in composition the above analysis, which represents a sample from portions of the bed free from iron stain.

SURVEY NUMBER OF EXPOSURE C. NO. 316.

Edisto Area—Hood's Branch Sub-area—Lloyd Gunter.

6.0 miles east of Seivern (railway station), connected by road; 5.0 miles from nearest point railway. Bed adjacent and similar to C. No. 315. Also extends to the property of Mrs. Corrie Fallaw, C. No. 317, in obscure quantity.

SURVEY NUMBER OF EXPOSURE E. NO. 262.

Edisto Area—Sub-area—Three-Cornered Pond.

Location: Two miles east of Seivern.

Geognosy—Overburden: 0 to 3 feet. Thickness of clay: 12 feet. Drainage: Gravity.

Physical properties—Texture: Indurated, fine grained to gritty. Color: Light drab. Specific Gravity: 2.0.

Chemical analysis:

Silica	73.84
Alumina	14.92
Ferric Oxide	4.01
Lime	1.01
Magnesia	.64
Soda and Potash	Undetermined.
Ignition	4.00
Total	98.42

Remarks—A littoral deposit of Eocene siliceous clay; quite limited in extent. Borings in contiguous hill show that it does not enter the hill. Used for domestic structural purposes. As a fuller's earth it bleaches and filters well, but is somewhat gritty and affords a slight taste to culinary fats.

SURVEY NUMBER OF EXPOSURE P. NO. 270.

Edisto Area—Great Swamp Sub-area—Fishburne (F. C.).

0.25 miles west from Walterboro (railway station), connected by road.

For analysis (by R. & B.) see table of analyses.

Remarks—As a fuller's earth it affords good results with mineral oils. Analysis indicates a clay well adapted to the uses of the Cement manufacturer and to the manufacture of ordinary pottery.

SURVEY NUMBER OF EXPOSURE P. NO. 400.

Edisto Area—Cypress Swamp Sub-area—Fishburne (F. C.).

3.0 miles N. W. from Summerville (railway station), connected by road.

For analysis (by R. & B.) see table of analyses.

Remarks—As a fuller's earth it affords good results with mineral oils. Analysis indicates a clay well adapted to the uses of the cement manufacturer and to the manufacture of ordinary pottery.

SURVEY NUMBER OF EXPOSURE P. NO. 401.

Edisto Area—Cypress Swamp Sub-area—Fishburne (F. C.),

3.0 miles N. W. from Summerville (railway station), connected by road.

For analysis (by Heinrich Riess) see table of analyses.

Remarks—As a fuller's earth it affords good results with mineral oils. Analysis indicates a clay well adapted to the manufacture of ordinary pottery and to the uses of the cement manufacturer.

SANTEE AREA.

SURVEY NUMBER OF EXPOSURE C. NO. 503.

Santee Area—Congaree Creek Sub-area—Rock House.

7.5 miles south from Lexington (railway station), connected by road; 0.5 miles distant from Congaree Creek. A marginal bed highly irregular in extent. Under fire the body crazes; with glaze it affords a deep cream color.

SURVEY NUMBER OF EXPOSURE C. NO. 505.

Santee Area—Congaree Creek Sub-area—Moulton Place.

Location: 1 mile N. of Edmonds.

A bed of pisolitic kaolin of good quality but of very uncertain extent; the exposure being now largely obscured.

SURVEY NUMBER OF EXPOSURE C. NO. 510.

Santee Area—First Creek Sub-area—Goodwin Mill.

1.5 miles northwest from Gaston (railway station); connected by road; deposit close to First Creek, a stream of clear freestone water.

Thickness of bed: 12 feet. Thickness of overburden: 1 foot, with very irregular increase.

This bed of clay, which is of the Middendorf type is characteristically irregular in its distribution. In places it immediately underlies the Eocene grit, and apparently passes under the indurated Eocene fossiliferous clay.

Texture: Fine grained. Specific Gravity: 2.5. Color: Drab and pink. Plasticity. Good (27 per cent.). Tensile Strength: 8 pounds. At 1350 degrees C: Cream white body; 13 percent. shrinkage; absorption 15.7 per cent,; hardness, 4.

SURVEY NUMBER OF EXPOSURE C. NO. 515.

Santee Area—Thoms Creek Sub-area—Geiger (Mrs. H.).

Location: 3.0 miles north of Gaston (railway station); 0.1 miles from Columbia-Denmark Railroad; connected by road; 0.1 miles from Thoms Creek, a stream of clear freestone water.

Geognosy—Overburden: From 1 foot, rapidly increases. Thickness of clay: 5 to 12 feet. Drainage: Gravity.

Physical properties—Texture: Fine grained. Color: White and purple, patches of yellow. Specific Gravity: 2.6. Plasticity: Good (25.4 per cent.). Tensile Strength: 8 to 10 pounds. Slakes: Readily.

Pyrometric tests:

Furance Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	8.1	32.0	2.0	White	
1350 degrees C.	14.0	16.7	3.5	White	White
1350 degrees C.	Affords fine compact body.				

Chemical analysis:

Silica	45.44
Alumina	38.78
Ferric Oxide	1.15
Titanic Oxide	.98
Lime	.11
Magnesia	.12
Soda	.48
Potash	.23
Ignition	12.86
Total	100.15

Rational analysis:

Clay Substance	97.86
Quartz	.93
Feldspar	1.36
Total	100.15

Remarks—This deposit is exposed at two points and gives promise of fair extent.

As washed it affords the above analysis.

It is well adapted to the manufacture of the faience wares, affording a fine smooth white body, and developing very slight color under glaze.

SURVEY NUMBER OF EXPOSURE C. NO. 520.

Santee Area—Savannah Hunt Creek Sub-area—Wolfe (Archie).

6.0 miles N. E. from Gaston (railway station), connected by road; 1.3 miles from Congaree River. Exposed along the banks of a small branch.

Geognosy—Overburden: From 0 to 30 feet. Thickness: From 1 to 18 feet.

Physical properties—Texture: Varies from fine grained through micaceous to gritty. Color: Purple, with occasional patches of white, and in parts stained with iron oxide. Plasticity: Good (27.7 per cent.). Tensile Strength: 9 pounds. At 1350 degrees C.: Fine compact smooth body with a hardness of 3.5, a shrinkage of 15 per cent., a water absorption of 11 per cent. Under glaze it affords a light cream color.

SURVEY NUMBER OF EXPOSURE C. NO. 525.

Santee Area—Congaree Bluff on Congaree River at confluence with Savannah Hunt Creek.

7.3 miles N. E. from Gaston (railway station); connected by road.

Geognosy—Overburden: 15 to 35 feet. Thickness of clay: 8 feet. Drainage: Gravity, when river is not high.

Physical properties—Texture: Fine grained to slightly gritty. Color: Slate, with banded layers of pink.

Remarks—An extensive bed of Middendorf clay, which gradually declines southerly below the level of the Congaree River.

SURVEY NUMBER OF EXPOSURE C. NO. 550.

Santee Area—Crane Creek Sub-area—Carolina Fire Brick Co.

Location: 0.5 to 2.0 miles east of Killian (railway station); connected by tram track; 0.4 miles from Crane Creek.

Geognosy—Overburden: Slight, with gradual increase. Thickness of clay: From 5 to 15 feet. Drainage: Gravity.

Physical properties—Texture: Partly fine grained; partly gritty. Color: White, purple; some yellow patches. Specific Gravity: 2.35. Plasticity: Good (26.5 per cent.). Tensile Strength: 9 to 15 pounds. Slakes: Gradually.

Pyrometric tests (samples from high grade deposit):

Furance Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	14.5	23.7	3.5	Cr.-White	
1350 degrees C.	17.5	13.0	3.5	Cr.-White	Cream

Chemical analysis:

Silica.	42.30	57.30
Alumina.	36.94	23.82
Ferric Oxide.	2.64	2.94
Lime.	.80	1.59
Magnesia.	.78	1.51
Ignition	15.43	11.84
Total.	100.00*	100.00**

Remarks—The main deposit of clay pertaining to this tract gives strong promise of very great extent. The Carolina Fire Brick Company has a well equipped plant, which produces high grade refractory wares, and brick well adapted to resisting the acid gases of pyrites furnaces. Special grades are well adapted to lining "glass tanks," and blast furnaces. The daily capacity of this plant is 60,000 brick. The plant is located at Killian, on the Columbia-Charlotte Railway.

*1.11—Undetermined; analysis furnished by proprietor.
**1.00—Undetermined; analysis furnished by proprietor.

SURVEY NUMBER OF EXPOSURE C. NO. 560.

Santee Area—Gill's Creek Sub-area—Frank Hampton.

3.5 miles S. E. from Columbia (railway station); connected by road; 1 mile from Columbia-Florence Railroad; 0.3 miles distant from Gill's Creek.

Geognosy—Overburden: 4 feet, with moderate increase.

Physical properties—Color: Sub-white with some organic and iron stain. Plasticity: Good (28 per cent.). Tensile Strength: 11 pounds. At 2150 degrees C.: Good body with hardness of 4, a water absorption of 6.9, a shrinkage of 14 per cent, and a cream color. Glazes light yellow. This bed is obscured, but in a well showed a thickness exceeding 20 feet.

SURVEY NUMBER OF EXPOSURE C. NO. 563.

Santee Area—Gill's Creek Sub-area—Landrum Fire Brick Works.

Location: 4.3 miles N. E. of Columbia (C. H.); 3.3 miles from railway station; near Eight Mile Branch.

Geognosy—Overburden: 3 feet, with gradual increase. Thickness of clay: 3 to 5 feet. Drainage: Gravity.

Physical properties—Texture: Fine grained and in parts gritty. Color: Cream white.

Remarks—The output of the connected plant is about 900,000 fire bricks each year.

The above indicated Cretaceous clay, which is highly refractory, is mixed with a meta-residual clay afforded by disintegrated shales exposed on the premises. This meta-residual clay burns white and bonds the refractory clays, affording excellent results. Incipient vitrification of the meta-residual clay occurs at 1400 degrees C. This meta-residual clay has valuable possibilities in the potter's art.

SURVEY NUMBER OF EXPOSURE C. NO. 565.

Santee Area—Mill Creek Sub-area—Public Road (Columbia to Garner's Ferry).

Location: 7 miles S. E. of Columbia; 1 mile north of Columbia-Florence Railroad; connected by road; near the head of Mill Creek.

Geognosy—Overburden: 9 feet, with gradual increase. Thickness of clay: 8 feet exposed. Drainage: Gravity.

Physical properties—Color: Drab and pink. Specific Gravity: 2.5. Plasticity: Good (27.6 per cent.). Tensile Strength: 10 to 15 pounds. Slakes: Gradually to pale gray slip.

Pyrometric tests:

Furance Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	5.4	20.6	3	Dirty-w.	
1350 degrees C.	15.0	4.0	4	Gray-w.	Cream
1350 degrees C.	Very dense body, incipiently vitrified.				

Chemical analysis:

Silica	49.31
Alumina	34.38
Ferric Oxide	1.91
Titanic Oxide	1.10
Lime	.18
Magnesia	.16
Soda	.21
Potash	.20
Ignition	12.52
Total	99.97

Rational analysis:

Clay Substance	91.72
Quartz	7.16
Feldspar	1.09
Total	99.97

Remarks—This is a very characteristic deposit of Middendorf clay. Its extent is obscure.

SURVEY NUMBER OF EXPOSURE C. NO. 570.

Santee Area—Cedar Creek Sub-area—Smith (J. F.).

Location: 2.8 miles N. W. of Congaree (railway station); 1.25 miles N. of Columbia-Florence Railway, connected by road; 0.0 miles from Cedar Creek, a stream of clear freestone water.

Geognosy—Overburden: 0 to 26 feet. Thickness of clay: 6 to 12 feet. Drainage: Gravity.

Physical properties—Texture: Mainly fine grained, portions slightly gritty, and slightly micaceous. Color: White through an average depth of four feet; balance purple stained. Specific Gravity: 3.1. Plasticity: Good. Tensile Strength: 10 to 20 pounds. Slakes: Very slowly.

Pyrometric tests:

Furance Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	13.2	20.2	2.5	White	
1350 degrees C.		13.4	4.0	White	Cream-w.
1350 degrees C. . . Affords compact body with very slight checking.					

Chemical analysis:

Silica	45.72
Alumina	38.96
Ferric Oxide	.93
Titanic Oxide	.98
Lime	.06
Magnesia	.07
Soda	.55
Potash	.19
Ignition	13.05
Total	100.51

Rational analysis:

Clay Substance	98.39
Quartz	1.21
Feldspar	.91
Total	100.51

Remarks—This deposit is admirably situated for mining and for washing; it occurs along a scarp adjacent and superior to Cedar Creek. It has been exploited with satisfactory results over nine acres. Mixed with tougher clay it affords a good grade of faience ware, a small addition of the oxide of cobalt correcting the slight cream tint developed in glazing.

The above analysis is of a fair sample from the selected white.

SURVEY NUMBER OF EXPOSURE C. NO. 575.

Santee Area—Carter Creek Sub-area.

0.6 miles south from Acton (railway station); connected by road. Along tributary branch of Carter's Creek this bed of drab colored clay occurs, but is greatly obscured.

Specific Gravity: 2.2. Texture: Fine grained. Plasticity: Good (28 per cent.). Tensile Strength: 12 to 16 pounds. At 1350 degrees C.: Dirty gray body, with a hard vitrification. With glaze a brown color develops at the higher temperature. Shrinkage 19 per cent.

SURVEY NUMBER OF EXPOSURE C. NO. 590.

Santee Area—Colonel's Creek Sub-area—Thompson (J.).

Location: 9 miles (air line) north of Congaree (railway station); connected by road.

Geognosy—Overburden: 16 feet, with gradual increase. Thickness of clay: 11 feet colored, 20 feet white and in parts micaceous. Drainage: Gravity.

Physical properties—Texture: Upper portion fine grained, lower portion fine grained but in places micaceous. Color: White, purple and yellow. Specific gravity: 2.45. Plasticity: Good (26.2 per cent.).

Tensile Strength: 7 to 10 pounds. Slakes: Readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	9.5	26.8	3	White	
1350 degrees C.	15.0	12.1	4	White	Cream-w.
1350 degrees C.	Compact body, with very slight checking.				

Chemical analysis:

Silica.	47.78
Alumina.	37.26
Ferric Oxide.	1.26
Titanic Oxide.	1.07
Lime.	.07
Magnesia.	.11
Soda	.63

Potash.	.10
Ignition.	12.29
Total.	100.57

Rational analysis:

Clay Substance.	95.48
Quartz.	3.17
Feldspar.	1.92
Total.	100.57

Remarks—While this deposit presents a fine exposure, its full extent in the absence of test pits is a matter of conjecture, although its probabilities are good.

SURVEY NUMBER OF EXPOSURE C. NO. 595.

Santee Area—Jumping Run Sub-area—Sloan (S.).

In the air line 8 miles north from Congaree (railway station); connected by road; 1.5 miles distant from Colonel's Creek.

Color: Purple gray and mottled. Texture: In part fine grained, and in part gritty. Plasticity: Good. Tensile Strength: 21 to 26 pounds. At 1350 degrees C.: It affords a yellow body with a hardness of 4, a shrinkage of 18 per cent., and absorption of 5.30 per cent.

SURVEY NUMBER OF EXPOSURE C. NO. 600.

Santee Area—Cook's Mount.

7 miles N. E. from Acton (railway station); connected by road; 0.0 miles distant from Pee Dee River.

Thickness of bed: 16 feet, separated from upper gritty bed by 11 feet. Thickness of overburden: 40 feet, with abrupt increase. Texture: Gritty at top, micaceous at bottom. Specific Gravity: 2.40. Tensile Strength: 12 pounds. Microscope reveals particles of hornblende. At 1350 degrees C.: Dense body with light cream-color. Hardness 3.5, shrinkage 19 per cent., absorption 7.5 per cent. Glazing develops decided yellow color.

SURVEY NUMBER OF EXPOSURE C. NO. 605.

Santee Area—Gilmore Hill.

10.0 miles N. E. from Acton (railway station); connected by road; 1.2 miles distant from Wateree River.

Lower bed exposed in gully adjacent to hill affords a fine grained, highly purple clay. Specific Gravity: 2.5. Plasticity: Good (25.5 per cent.). Tensile Strength: 6 to 8 pounds.

At 1350 degrees C.: Good white body, with a hardness of 3.5, absorption 16 per cent., shrinkage 15 per cent. Glazing develops a faint cream color, almost white.

The character of this clay entitles its extent to reasonable investigation by owner.

SURVEY NUMBER OF EXPOSURE C. NO. 619, NO. 620, NO. 621.

Santee area.

Location—On the Columbia-Camden Railway at successive points from Jacobs to Blaneys, limited patches of Middendorf clays suitable for mixing with the more refractory clays in the manufacture of refractory wares.

SURVEY NUMBER OF EXPOSURE C. NO. 630.

Santee Area—Beech Creek Sub-area—Railway right of way.

0.6 miles east from Camden Junction (railway station), and alongside Columbia-Florence Railroad; connected by road.

Thickness of bed: 8 feet of mixed white and red clay, containing much fine grained pyrites. Thickness of overburden: 5 feet with rapid increase.

SURVEY NUMBER OF EXPOSURE C. NO. 635.

Santee Area—Beech Creek Sub-area.

1.5 miles distant from Claremont (railway station); connected by road; 0.3 miles distant from Beech Creek, a stream of clear freestone water.

Bed of gritty clay, varying in thickness from nil to 20 feet. Thickness of overburden: From five feet gradually increases. Affords a very fair grade of fire clay, showing limited vitrification at 1400 degrees C.

SURVEY NUMBER OF EXPOSURE C. NO. 640.

Santee Area—Rafting Creek Sub-area—Rembert (E.).

Location: 1.0 mile S. W. from Rembert (railway station); 0.1 mile from Rafting Creek.

Geognosy—Overburden: 2.5 feet, with gradual increase. Thickness of clay: 12.0 feet. Drainage: Gravity.

Physical properties—Texture: Fine grained. Color: Dark slate, pink and white. Specific Gravity: 2.7. Plasticity: Good (26.6 per cent.). Tensile Strength: 30 to 33 pounds. Slakes: Gradually.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	12	26.6	3	Cr-white	
1350 degrees C.	19	2.9	4	Light Cream	Deep Cream

1350 degrees C., Fine smooth dense body.

Remarks—This deposit of Middendorf clay is highly irregular in its thickness and continuity.

SURVEY NUMBER OF EXPOSURE C. NO. 645.

Santee Area—Swift Creek Sub-area—Murchison.

Location: 6 miles S. E. from Camden (railway station).

Geognosy—Overburden: 8 feet, with gradual increase. Thickness of clay: 8 feet, of the better grade. Drainage: Gravity.

Physical properties—Texture: Fine grained. Specific Gravity: 2.2. Plasticity: Moderate (23 per cent.). Tensile Strength: 40 to 59 pounds. Slakes: Gradually.

Chemical analysis:

Silica	47.46	52.34	55.94	59.74
Alumina	36.83	34.02	30.82	28.46
Ferric Oxide	2.60	2.05	2.05	2.01
Lime	.22	.31	.23	.26
Magnesia	.13	——	.12	.20
Soda and Potash, Undetermined.				
Ignition	12.97	11.54	10.31	9.57
Total	100.21	100.26	99.47	100.24

Remarks—A good clay to mix with the more refractory Cretaceous clays in the manufacture of the finer faience wares.

Indications of the occurrence of clay of similar character are observed at C. No. 648 (Shannon's Hill), and at C. No. 650 (the basin in which Swift Creek originates).

SURVEY NUMBER OF EXPOSURE C. NO. 655.

Santee Area—Pine Tree Creek Sub-area—Camden Press Brick Company.

Location: 1.0 mile south of Camden Courthouse; 0.4 mile west of railway, connected by spur track; 0.1 miles from Pine Tree Creek.

Geognosy—Overburden: 5 feet, with gradual increase. Thickness of clay: 4 to 6 feet. Drainage: Gravity.

Physical properties—Texture: Varies from fine grained to gritty. Color: Gray and yellowish white. Specific Gravity: 2.5. Plasticity: Good (25.2 per cent.). Tensile Strength: 24 to 32 pounds. Slakes: Gradually to drab slip.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1350 degrees C.	13.0	18.1	3.5	Sub-W.	Cream

*Chemical analysis:**

Silica	57.65
Alumina	30.50
Ferric Oxide	1.72
Ignition	8.85
Undetermined	1.28
Total	100.00

Remarks—This clay deposit affords a good fire brick as manufactured by the proprietors.

It is apparently a bed of good extent and is most conveniently situated.

This property affords a very excellent deposit of superior alluvial clay, which is extensively utilized in the manufacture of common and repressed brick.

*The above analysis was furnished by the proprietor.

SURVEY NUMBER OF EXPOSURE C. NO. 670.

Santee Area—Sanders Creek Sub-area—Villepigue (K.).

5.0 miles north from Camden (railway station); 0.1 miles from Camden-Blacksburg Railroad, connected by road; 0.4 miles distant from Sanders Creek, a stream of clear freestone water.

Kaolin of fair quality taken from well. A fair sample could not be obtained for testing.

SURVEY NUMBER OF EXPOSURE C. NO. 675.

Santee Area—Pine Tree Creek Sub-area—Welsh (J.).

3.0 miles east from Shepard (railway station), and alongside railway track; connected by road; 0.1 miles distant from Pine Tree Creek.

Thickness of bed: 7 feet of purple and drab clay. Thickness of overburden: 11 feet.

SURVEY NUMBER OF EXPOSURE E. NO. 505.

Santee Area—First Creek Sub-area—Williams (Elmore).

Location: 0.9 miles N. W. Gaston (railway station); connected by road.

Geognosy—Overburden: 0 to 8 feet. Thickness of clay: 8 feet exposed. Drainage: Gravity.

Physical properties—Texture: Semi-indurated. Color: Pale gray. Specific Gravity: 2.0.

Chemical analysis:

Silica	81.65
Alumina	7.66
Ferric Oxide	1.93
Lime	3.12
Magnesia	2.01
Ignition	3.58
Total	99.95

Remarks—Bleaches and filters satisfactorily, but prejudices odor and taste of cottonseed oil.

SURVEY NUMBER OF EXPOSURE E. NO. 605 AND NO. 606.

Santee Area—Fuller's Earth Creek Sub-area.

Location: 5.0 miles south of Manchester (railway station), on Fuller's Earth Creek; connected by road.

Geognosy—Overburden: 0 to gradual increase. Thickness of clay: 30 feet exposed. Drainage: Gravity.

Physical properties—Texture: Upper part gritty; lower part fine grained. Color: Drab.

Chemical analysis:

Silica	86.80	78.64
Alumina	4.83	10.10
Ferric Oxide	2.81	5.81
Lime	0.37	0.82
Magnesia	0.42	0.41
Ignition	4.63	3.20
Total	99.86	98.98

Remarks—Bleaches cottonseed oil and mineral oils with good results excepting the taste imparted to the culinary oil.

SURVEY NUMBER OF EXPOSURE P. NO. 575.

Santee Area—St. Stephens Sub-area.

Location: Within municipal limits of St. Stephens.

Drainage: Power.

Physical properties—Texture: Fine grained to slightly gritty.

Chemical analysis:

Silica	62.38
Alumina	19.40
Ferric Oxide	4.69
Titanic Oxide	1.23
Lime	.26
Magnesia	.93
Soda	.28
Potash	1.60
Sulphur	.66
Sulphuric Acid	1.04
Iron Pyrites	1.24
Ignition	6.91
Total	99.96

Rational analysis:

Clay Substance	59.44
Quartz	30.60
Feldspar	9.92
Total	99.96

Remarks—Furnace tests show this to be a very good brick clay, except for the blistering effects produced by the liberation of the sulphuric anhydride at high temperatures.

SURVEY NUMBER OF EXPOSURE Y. NO. 570.

Santee Area—Horse Pen Creek Sub-area—Rollings (J. C.).

Location: 2.0 miles north of the Columbia-Camden Railroad.

Geognosy—Overburden: 5 feet, with rapid increase. Thickness of clay: Indeterminate.

Physical properties—Texture: Granular and slightly gritty. Color: Drab to gray. Specific Gravity: 2.3. Plasticity: Low (18.7 per cent.). Tensile Strength: 4 to 12 pounds. Slakes: Readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	6.6	14.7	2.0	Buff	
1350 degrees C.	8.5	11.9	2.5	Buff	Gray Yel.

Chemical analysis:

Silica	72.37
Alumina	16.88
Ferric Oxide	2.26
Lime	.33
Magnesia	.91
Soda	.08
Potash	3.17
Ignition	3.84
Total	99.84

Remarks—This material represents slightly altered shales; they prevail to a great extent along Gill's Creek and its tributaries, where they afford valuable clays for bonding the more refractory Cretaceous clays.

SURVEY NUMBER OF EXPOSURE R. NO. 549.

Santee Area—Cayce Sub-area—Guignard Brick Works.

Location: On bank of Congaree River opposite Columbia, and 0.6 mile north of Cayce (railway station); connected by spur track.

Drainage: Gravity and power.

Physical properties—Specific Gravity: 2.5. Plasticity: Good. Tensile strength: 65 to 85 pounds.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1170 degrees C.	12	10.8	3.0	Red	
1190 degrees C.	13	9.5	3.5	Red-Brown	
1230 degrees C.	15	7.0	4.0	Brown	

Chemical analysis:

Silica	60.19
Alumina	22.18
Ferric Oxide	4.41
Titanic Oxide	1.04
Lime	.49
Magnesia	.81
Soda	1.19
Potash	1.49
Ignition	7.98
Total	99.78

Rational analysis:

Clay Substance	63.12
Quartz	24.72
Feldspar	11.94
Total	99.78

Remarks—An extensive deposit of alluvial clay, which is utilized by a well equipped plant for the manufacture of a superior grade of common and repressed brick.

These details of the properties of the clay are given as typical of the deposits of alluvial clays of this section.

PEE DEE AREA.

SURVEY NUMBER OF EXPOSURE C. NO. 775.

Pee Dee Area—Black River Sub-area—Evans (Hugh).

Location: 5.0 miles N. E. from Rembert (railway station); connected by road.

Geognosy—Overburden: 3 feet, with rapid increase. Thickness of bed: 6.0 feet white; 4.5 feet drab color.

Physical properties—Texture: Fine grained: Specific Gravity: 2.5. Plasticity: Good (26 per cent.). Tensile Strength: 10 to 12 pounds.

At 1350 degrees C.: Good compact body, with a hardness of 3.5, absorption 16 per cent. shrinkage 18 per cent. Glazing develops cream color.

SURVEY NUMBER OF EXPOSURE C. NO. 780.

Pee Dee Area—Scapo Creek Sub-area—Pate's Mill.

Location: 5.5 miles S. W. from Lucknow (railway station); connected by road; on both sides of Scapo Creek, a stream of clear free stone water.

Geognosy—Thickness of overburden: 3 feet, with gradual increase. Thickness of bed: 40 feet.

An enormous deposit of clay, of drab and pink color, but difficult of access. The clays exposed along Scapo Creek are excellently adapted to the manufacture of high grade face brick and tiles of light color—some fair fire clay.

SURVEY NUMBER OF EXPOSURE C. NO. 785.

Pee Dee Area—Juniper Creek Sub-area—Cobert Hill.

Location: 3.9 miles S. E. of Middendorf (railway station); connected by road.

Geognosy—Overburden: 22 feet, with gradual increase. Thickness of clay: 4 feet to 18 feet. Drainage: Gravity.

Physical properties—Texture: Fine grained. Color: Drab and pink. Specific Gravity: 2.5. Plasticity: Fair (21.5 per cent.). Tensile Strength: 9 to 11 pounds. Slakes: Gradually to gray slip.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.		24.0	2.5	Cr.-white.	
1350 degrees C.	14.5	16.0	3.5	Cr.-white	Yellow

1350 degrees C., affords good compact smooth body.

Chemical analysis:

Silica	55.02
Alumina	32.32
Ferric Oxide	1.23
Titanic Oxide	1.27
Lime	.16
Magnesia	.23
Soda	.56
Potash	.28
Ignition	9.27
Total	100.34

Rational analysis:

Clay Substance	81.93
Quartz	16.24
Feldspar	2.17
Total	100.34

Remarks—This represents a large deposit of clay. Its analysis should suggest a highly refractory clay, but the extreme fineness of particles greatly reduces the point of incipient fusion. It could be used with refractory clays of higher tensile strength in the potter's mixtures.

SURVEY NUMBER OF EXPOSURE C. NO. 790.

Pee Dee Area—Black Creek Sub-area.

2.0 miles east from Middendorf (railway station); connected by road. Exposed in excavation of Camden-Cheraw Railroad (37 M. P.).

Thickness of bed: 5.4 feet. Thickness of overburden: 30.0 feet, with increase northerly. Encloses numerous fossil leaves.

SURVEY NUMBER OF EXPOSURE C. NO. 795.

Pee Dee Area—Bear Creek Sub-area.

Location—Sugar Loaf Mountain, 3.0 miles N. E. from Middendorf (railway station); connected by road.

Geognosy—Overburden: 1 foot, with rapid and irregular increase. Thickness of clay: 21 feet, highly irregular. Drainage: Power.

Physical properties—Texture: Fine grained. Color drab. Specific Gravity: 2.5. Plasticity: Good (27.6 per cent.). Tensile Strength: 12 to 20 pounds. Slakes: Gradually.

Pyrometric tests:

Temperature Furnace	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	10.2	10.3	3	Mauve	Cream
1350 degrees C.	15.0	9.0	4	Mauve	Cream

1350 degrees C., dense smooth body.

Chemical analysis:

Silica	66.06
Alumina	23.88
Ferric Oxide	1.02
Lime	.26
Ignition	8.10
Undetermined	.68
Total	100.00

Remarks—Deposit is irregularly distributed.

SURVEY NUMBER OF EXPOSURE C. NO. 800.

Pee Dee Area—Bear Creek Sub-area—Goodale (W. H.).
5.0 miles north of Middendorf (railway station); connected by road.
Thickness of bed: 8.03 feet drab and pink clays.

SURVEY NUMBER OF EXPOSURE C. NO. 805.

Pee Dee Area—Juniper Creek Sub-area.
Between Middendorf and Patrick (railway station); along railway, numerous thin exposures of white clay.

SURVEY NUMBER OF EXPOSURE C. NO. 810.

Pee Dee Area.
Location: .06 mile distant from Cheraw (railway station); in excavation of Cheraw and Hamlet Railroad.
Geognosy—Overburden: 10 to 26 feet. Thickness of bed: 4 feet to 9 feet coarse, gritty white and red clay.
Physical properties—Texture: Crude gritty clay.

SURVEY NUMBER OF EXPOSURE C. NO. 820.

Pee Dee Area—Cedar Creek Sub-area—Evans' Mill (Mrs. Godfrey).
Location: 1.1 mile N. W. of Society Hill (railway station); and on both sides of Cedar Creek.
Geognosy—Overburden: 4 feet, with gradual increase. Thickness of clay: 9 feet. Drainage: Gravity.
Physical properties—Texture: Fine grained at top, gritty at bottom. Specific Gravity: 2.5. Plasticity: Good (25.7 per cent.). Tensile Strength: 48 to 60 pounds. Slakes: Readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	14	8	3	Yellow	Red-Yellow
1250 degrees C.	19	0	4	Vitrification	

Chemical analysis:

Silica	53.87
Alumina	29.23
Ferric Oxide	3.07
Titanic Oxide	1.48
Lime	.37
Magnesia	.27
Soda	.73
Potash	.98
Ignition	10.28
Total	100.28

Rational analysis:

Clay Substance	76.45
Quartz	18.60
Feldspar	5.23
Total	100.28

Remarks—This deposit affords a good bed of potter's clay, adapted to the manufacture of common potter's ware and high grade ornamental brick.

SURVEY NUMBER OF EXPOSURE C. NO. 825.

Pee Dee Area—Hurricane Creek Sub-area—Floyd's Mill.
Location: 7.2 miles N. E. from Darlington (railway station); along south side Hurricane Creek; about 2.25 miles from Darlington-Bennettsville Railroad.
Geognosy—Overburden: 0 to 45 feet. Thickness of clay: 5.3 feet exposed above water level. Drainage: Power.
Physical properties—Texture: Fine grained. Color: Grayish black. Plasticity: Good (26.9 per cent.). Tensile Strength: 66 to 100 pounds. Slakes: Well.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness Per Cent.	Biscuit Color	Color Glazed
1210 degrees C.	14.5	1.5	4	Yellow-red	
1350 degrees C.	17.5	0.0	4	Sienna	Brown

1350 degrees C., vitrified smooth body.

Chemical analysis:

Silica	66.27
Alumina	18.03
Ferric Oxide	5.15
Titanic Oxide	1.70
Lime	.70
Magnesia	.42
Soda	.67
Potash	1.27
Ignition	6.16
Total	100.37

Rational analysis:

Clay Substance	55.27
Soluble Silica	12.26
Quartz	27.21
Feldspar	5.63
Total	100.37

Remarks—This clay affords a fine vitrified ware.

SURVEY NUMBER OF EXPOSURE C. NO. 860.

Pee Dee Area—Bigham Branch Sub-area.

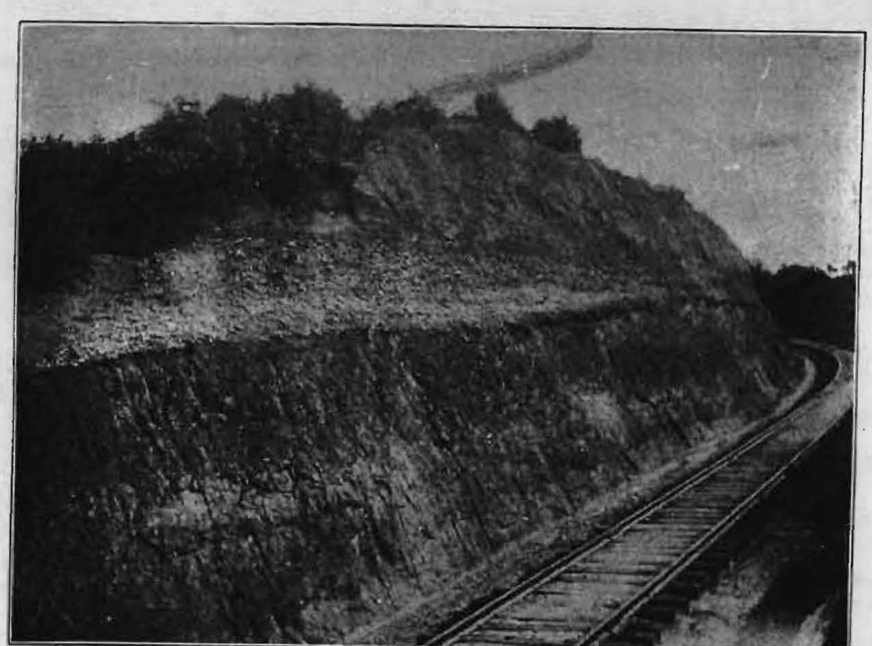
Location: 0.9 miles N. W. Dewett's Bluff (Pee Dee River); along Bigham Branch. Transportation facilities: Pee Dee River.

Geognosy—Overburden: 0 to 43 feet. Thickness of clay: Exposed 8 feet (borings 225/240 feet). Drainage: Gravity.

Physical properties—Texture: Fine grained. Color: Black, wet; dark gray, dry. Specific Gravity: 2.3. Plasticity: Good. Tensile Strength: 88 to 137 pounds. Slakes: Slowly.

PLATE VIII.

CRETACEOUS AND TERTIARY CLAYS—FLOYD'S MILL, DARLINGTON COUNTY.



LOWER CRETACEOUS CLAYS WITH LAFAYETTE COBBLESTONES SUPERIMPOSED.

Pyrometric tests:

Furnace Temperature	
1100 degrees C.:	Affords moderately hard compact brick ware.
1130 degrees C.:	Fuses to a green slag.

Chemical analysis:

Silica	39.87
Alumina	10.97
Ferric Oxide	3.32
Titanic Oxide	Trace.
Lime	20.69
Magnesia	0.97
Soda	0.83
Potash	1.67
Carbonic Acid	15.64
Phosphoric Acid	0.27
Sulphuric Acid	0.38
Sulphur (with iron)	1.52
Iron (with sulphur)	1.32
Ignition	2.19
Total	99.64

Rational analysis:

Clay Substance	33.66
Quartz	17.46
Feldspar	8.87
Calcium Carbonate	35.58
Calcium Phosphate	0.59
Calcium Sulphate	0.64
Iron Pyrites	2.84
Total	99.64

Remarks—This clay-marl constitutes a very extensive bed 225 to 240 feet in thickness. The margin of temperature between vitrification and fusion is too small to admit of proper control in the manufacture of vitrified wares.

Similar clay-marl to that at Bigham Branch (C. No. 860) occurs at Burches' Ferry (C. No. 885), Dewett's Bluff (C. No. 861), Davis' Landing (C. No. 867), with characteristic fossils, underlying from 20 to 60 feet of marls, sands, etc.

SURVEY NUMBER OF EXPOSURE E. NO. 800.

Pee Dee Area—Suder (A. W.).
Location: Clarendon County
Geognosy—Overburden: 3 feet. Thickness of clay: 5 feet.

Chemical analysis:

Silica	79.43
Alumina	10.70
Ferric Oxide	2.57
Titanic Oxide	.55
Lime	.58
Magnesia	1.05
Soda	.23
Potash	1.21
Ignition	3.94
Total	100.26

Rational analysis:

Clay Substance	33.78
Soluble Silica	19.01
Quartz	43.60
Feldspar	3.87
Total	100.26

Remarks—Bleaches and filters very satisfactorily, and affords very little odor or taste to the oil. (Sample furnished by the proprietor).

Alongside the course of Black River through parts of Clarendon and Williamsburg Counties intermittent exposures of a fuller's earth occur in beds of apparently considerable thickness. The samples tested are admirably adapted to the treatment of mineral oils with which they fulfill the bleaching and filtration requirements; experiments have been instituted with a view to correcting the cause of the slightly disagreeable odor and flavor imparted to the culinary fats and oils by the clay from these beds. The survey contemplates the further investigation of the merits of these beds.

The upturned edges of the shales affording the meta-residual clays are intermittently exposed along the fall line of this area in many prominent beds. They are conspicuously observed on Little Black Creek (Y. No. 799), near Ruby (Y. No. 800 and No. 801), at Chesterfield (Y. No. 803), at the Watson Place (Y. No. 810), and contiguous to the Cheraw-Wadesboro Railway, seven miles north of Cheraw (Y. No. 811).

Y. No. 800 and Y. No. 810 may be regarded as typical of these clays.

SURVEY NUMBER OF EXPOSURE Y. NO. 800 AND NO. 801.

Pee Dee Area—Sub-area—McGregor Place.

Location: Y. No. 800, 1.0 mile east of Ruby. Y. No. 801, 0.2 mile northeast of Ruby.

Geognosy—Overburden: 0 to 6 feet. Thickness of clay: Indeterminable. Drainage: Gravity.

Physical properties—Texture: Fine grained and lightly unctuous. Color: Zones of white and zones of pink and red. Specific Gravity: 2.5. Plasticity: Fair (24.4 per cent.). Tensile Strength: 2 to 6 pounds. Slakes: Readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	9.5	12.1	3	Cream	
1350 degrees C.	15.8	4.6	4	Cream	Cr'm Gray
1400 degrees C.	16.0	.8	4	Gray	

1400 degrees C., thoroughly vitrified to dense smooth body.

Chemical analysis:

Silica	67.38
Alumina	20.49
Ferric Oxide	2.72
Titanic Oxide	1.12
Lime	.14
Magnesia	.81
Soda	.09

Potash	2.55
Ignition	5.08
Total	100.38

Rational analysis:

Clay Substance	54.83
Quartz	38.34
Feldspar	7.21
Total	100.38

Remarks—This clay is too low in tensile strength to be self-sufficient for pottery, but m.xed with a tougher clay should afford good results.

SURVEY NUMBER OF EXPOSURE Y. NO. 810.

Pee Dee Area—Sub-area—Watson Place.

Location: 6.0 miles north of Cheraw (railway station); 0.1 mile from Cheraw-Wadesboro Railway.

Geognosy—Overburden: 3 to 7 feet. Thickness of clay: Indeterminable. Drainage: Gravity.

Physical properties—Texture: Fine grained to slightly gritty. Color: Gray. Specific Gravity: 2.8. Plasticity: 26.5. Tensile Strength: 31 to 37 pounds. Slakes: Readily.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1210 degrees C.	11.5	8.1	3.0	Red	
1350 degrees C.	18.0	0.0	3.5		Yel-Brown

1350 degrees C., vitrified to dense smooth strong body.

Chemical analysis:

Silica	61.62
Alumina	23.82
Ferric Oxide	3.38
Titanic Oxide	1.19
Lime	.33

Magnesia	.39
Soda	.72
Potash	1.43
Ignition	7.58
Total	100.46

Rational analysis:

Clay Substance	59.68
Quartz	28.08
Feldspar	12.70
Total	100.46

Remarks—This shale affords an excellent brick clay, upon being ground.

SURVEY NUMBER OF EXPOSURE R. NO. 819.

Pee Dee Area—Society Hill Sub-area—Darlington Brick Company.

Location: 0.5 mile east of Society Hill (railway station); connected by spur track; on bank of Pee Dee River.

Drainage: Gravity.

Physical properties—Texture: Fine grained and gritty. Color: Dun. Specific Gravity: 2.5. Plasticity: Good (28.1 per cent.). Tensile Strength: 43 to 54 pounds. Slakes: Very gradually.

Pyrometric tests:

Furnace Temperature	Air and Fire Shrinkage Per Cent.	Water Absorption, Per Cent.	Biscuit Hardness	Biscuit Color	Color Glazed
1150 degrees C.	14.5	12.7	3.5	Red	
1170 degrees C.	15.0	8.6	4.0	Red-brown	
1190 degrees C.	18.0	6.7	4.0	Red-brown	
1230 degrees C.	18.0	6.5	4.0	Brown	

Chemical analysis:

Silica	61.46
Alumina	19.44
Ferric Oxide	7.44

Manganese Oxide	.34
Titanic Oxide	.69
Lime	.58
Magnesia	.92
Soda	.67
Potash	1.15
Ignition	6.91
Total	99.60

Rational analysis:

Clay Substance	59.22
Quartz	29.81
Feldspar	10.57
Total	99.60

Remarks—This represents an extensive alluvial deposit which is equipped with a large plant producing an excellent grade of common and repressed brick. A temperature of 1190 degrees C. to 1210 degrees C. is necessary to correct porosity resulting from the appreciable amount of organic matter present. These details are given to indicate the type of alluvial brick clays occurring in this section.

ANALYSES OF SOUTH CAROLINA CLAYS.

AREA.	Place of Occurrence.	Survey Number of Exposure.	Silica.	Alumina.	Ferric Oxide.	Titanic Oxide.	Lime.	Magnesia.	Soda.	Potash.	Ignition.	Sundry Components.	Total.
AIKEN AREA—													
Horse Creek Valley	McNamee	C No. 100	45.02	38.98	.77	.85	.03	.07	.55	.26	13.58	....	100.11
Wise Creek Valley	Immaculate Kaolin Co.	C No. 150	44.23	38.92	2.31	1.21	.12	trace	.26	.30	12.90	....	100.25
Wise Creek Valley	Peerless Clay Co.	C No. 155	44 66	37.90	2.53	1.29	.08	trace	.41	.36	13.17	....	100.40
Wise Creek Valley	Harrigals	C No. 168	48.95	35.49	1.11	.43	none	none	.63	.50	12 97	....	100 08
Wise Creek Valley	Richards	C No. 175	47.49	35.56	2.47	.94	trace	trace	.74	.13	12.86	....	100.19
Wise Creek Valley	Sharpton	C No. 180	50.87	31.49	2.44	1.20	.32	.25	1.01	.63	11 42	....	99.63
Bridge Creek Valley	Graniteville Mfg. Co.	C No. 181	55.61	27.44	1.60	1.82	.14	.19	2.51	.33	10.39	....	100.03
Beaver Pond Valley	McMillan	C No. 195	44.51	38.12	1 75	1.11	.06	trace	.41	.32	13.45	....	99.73
Horse Creek Valley	*Sterling Kaolin Co.	C No. 205	43 18	37.36	.91	....	....	.50	....	2.00	14.32	....	98.27
Horse Creek Valley	Langley Mfg. Co., I 5 M., NE Langley	C No. 210	45.07	35.61	2.21	1.56	.16	.25	1.37	1.10	12.39	....	99.72
Near Garnett	Robert's (P)	P No. 10	64 22	20.15	5 22	.81	.32	.14	1.08	1 08	7.36	....	100 38
Savannah Valley	Hamburg	Y No. 10	75 20	15 45	1.79	.56	.34	.22	.27	.96	5.23	....	100.02
Savannah Valley	Abbeville	X No. 55	72 81	14 90	1.93	....	.56	.36	3.21	4.16	1 99	....	99.92
Savannah Valley	Edgefield	X No. 60	52.41	21.14	12.02	1.47	1.04	.56	1.12	.95	8.95	....	99.66
EDISTO AREA—													
Rocky Creek Valley	Brodie	C No. 260	44.11	38 19	1.55	1.30	.14	trace	.53	.50	13.37	....	99.60
Lightwood Creek	Keeslers	C No. 275	60.21	26.62	1.89	.91	.19	.24	.97	.67	8.58	....	100.28
Chalk Hill Creek Valley	Trenholm	C No. 295	46.99	36.08	1 02	.86	trace	trace	1.09	.20	13.82	....	100.06
Marbone Creek Valley	Imperial Kaolin Co.	C No. 300	45.69	37 47	1 01	1.44	trace	none	.69	.08	13.98	....	100.36
Hoods Brook Valley	Fallow (B)	C No. 315	45.10	38.69	1 28	1.00	.02	.03	.52	.37	13.52	....	100.53
Edisto Valley	Three Cornered Pond	E No. 262	73.84	14 92	4.01	....	1.01	.64	....	....	4 00	....	98.42
Walterboro	*Fishburne	P No. 270	61 15	24 83	2.34	....	.20	trace	trace	1.89	9.78	....	100.19
Summerville	*Fishburne	P No. 400	73.80	14 36	3.04	....	.22	trace	.06	2.14	6 31	....	99.93
Summerville	*Fishburne	P No. 401	60 90	23.61	2.39	....	1.75	1.36	....	1.10	9.60	....	100.51
SANTEE AREA—													
Thoms Creek	Geiger	C No. 515	45.44	38.78	1.15	.98	.11	.12	.48	.23	12.86	....	100.15
Crane Creek Valley	*Killian Fire Brick Co.	C No. 550	42.30	36.94	2.64	....	.80	.78	....	....	15.43	1.11	100.00
Crane Creek Valley	*Killian Fire Brick Co.	C No. 551	57.30	23.82	2.94	....	1.59	1.51	....	....	11 84	1.00	100.00
Mill Creek Valley	7 m.p. Garner F. Road	C No. 565	49.31	34 38	1.91	1.10	.18	.16	.21	.20	12.52	....	99.97
Cedar Creek Valley	Smith	C No. 570	45.72	38 96	.93	.98	.06	.07	.55	.19	13.05	....	100.51
Colonels Creek Valley	Thompson	C No. 590	47 78	37.26	1.26	1.07	.07	.11	.63	.10	12.29	....	100.57
Swift Creek Valley	Murchison	C No. 645	47 46	36.83	2 60	....	.22	.13	Undetermined		12.97	....	100.21
Swift Creek Valley	Murchison	C No. 645	52.34	34.02	2 05	....	.31	....	Undetermined		11.54	....	100.26
Swift Creek Valley	Murchison	C No. 645	55.94	30.82	2 05	....	.23	.12	Undetermined		10.31	....	99.72
Pine Tree Creek Valley	*Camden P. Brick Co.	C No. 655	57 65	30 50	1.72	....	....	....	Undetermined		8.85	Undetermined 1.28	100.00
First Creek.	Williams	E No. 505	81 65	7.66	1.93	....	3.12	2.01	....	....	3.58	....	99.95
Clarendon	Suder	E No. 600	79.43	10.70	2.57	.55	.58	1.05	.23	1.21	3.94	(Soluble Silica 19 01)	100.26
Fuller's Earth Creek	Manning (Gov.)	E No. 605	86.80	4 83	2.81	....	.37	.42	....	....	4.63	....	99 86
Fuller's Earth Creek	Manning (Gov.)	E No. 606	78.64	10.10	5.83	....	.82	.41	....	....	3.20	....	98.98
Santee Valley	St. Stephen	P No. 575	62.38	19.40	4 69	1.23	26	.93	.28	1.60	6.91	Sulphur 0.66 H_2SO_4 1.04 $Fe S_2$ 1.24	99.96
Giles Creek Valley	Dent's Pond	Y No. 560	53.19	33.41	1.67	.37	.10	.25	.12	.66	10 63	....	100.40
Horse Pen Creek	Rollings	Y No. 570	72 37	16 88	2.26	....	.33	.91	.08	3.17	3.84	....	99.84
Cayce	Guignard Brick Works	R No. 549	60.19	22.18	4 41	1 04	.49	.81	1.19	1.49	7.98	....	99.78
PEE DEE AREA—													
Juniper Creek	Cobert Hill	C No. 785	55.02	32.32	1 23	1.27	.16	.23	.56	.28	9.27	....	100.34
Bear Creek Valley	Sugar Loaf Mt.	C No. 795	66.06	23.88	1.02	....	.26	....	....	....	8.10	....	100.00
Cedar Creek	Evans Mill	C No. 820	53.87	29 23	3.07	1.48	.37	.27	.73	.98	10.28	....	100.28
Hurricane Creek Valley	Floyds Mill	C No. 825	66.27	18.03	5.15	1.70	.70	.42	.67	1.27	6.16	(Soluble Silica 12.26)	100.37
Black Creek Valley	Williamson (B)	E No. 835	58.31	11.16	6.92	....	.67	2.01	....	....	20.08	....	99.15
	Near Georgetown	P No. 800	80 10	6.73	2.87	....	.40	.49	....	....	7.71	Undetermined 1.70	100 00
Ruby	McGregor	Y No. 800	67 38	20 49	2.72	1.12	.14	.81	.09	2 55	5.08	....	100 38
A. C. L. R. R.	6 miles n. Cheraw	Y No. 810	61.62	23.82	3 38	1.19	.33	.39	.72	1.43	7.58	....	100.46
Society Hill	Darlington Brick Co.	R No. 819	61 46	19 44	7.44	.69	58	.92	.67	1 15	6.91	Mn O .34	99 60

CLAYS FROM THE CRYSTALLINE REGION.

AREA.	Place of Occurrence.	Survey Number of Exposure.	Silica.	Alumina.	Ferric Oxide.	Titanic Oxide.	Lime.	Magnesia.	Soda.	Potash.	Ignition.	Sundry Components.	Total.
Union County	Osbourne (A.B.)	X No. 550	54.40	30.14	2.10	....	.46	.54	.12	.87	11.37	....	100.00
Tucapau	Moore (Thomas E.)	X No. 555	60.90	18 82	5.74	....	.46	.32	....	....	12.33	1.43	100.00
Greenville	Williams (R.G.)	X No. 565	54.69	29 69	3.96	....	.57	.09	....	....	10.43	.57	100.00
Jonesville	Hamilton (R.W.)	X No. 570	52.46	26 81	1.79	....	.81	.33	....	....	14.44	3.36	100.00
Greenwood	Blake (W.K.)	X No. 575	54.40	29.14	3.50	....	.62	.30	.16	.66	11.72	....	100.50
Edgefield	Dr. Parker	X No. 155	52.41	21.14	12.02	1.47	1.04	.56	1.12	.95	8.95	....	99 66

*Analysis furnished by proprietor.

COMMON BRICK CLAYS.

As heretofore indicated, the most prominent beds of common brick clays occur at the points where the greater rivers (Savannah, Congaree, Wateree and Great Pee Dee) decrease their velocity upon entering the Coastal Plain; in addition to these alluvial deposits, numerous beds of sedimentary clay are exposed in the valleys of the lesser streams coursing through the Coastal Plain. In advance of a systematic examination of the Crystalline Area we cannot undertake to enumerate the large number of small deposits of residual and sedimentary clays occurring in that region; we submit a few typical analyses of such deposits.

Coastal Plain brick clays occur and have been utilized at the places indicated as follows:

SAVANNAH RIVER AREA.
- North Augusta.
  - Dunbar Brick Works.
  - Hahn (W. F.).
  - Hankinson & Son.
  - Merry Bros.
  - North Augusta Pottery Co.
  - Rosignal & O'Keefe.
  - Southern Pottery Co.

EDISTO AREA.
- Orangeburg.
  - Orangeburg Brick and Ice Co.
- Denmark.
  - Driggs (H. G.).
- Hardeeville.
  - Hardeeville Building Supply Co.
- Summerville.
  - Summerville Brick Works.
- Near Charleston.
  - Horlbeck (J. S.), Wando River.
  - Grant (C. McK.), Foster's Creek.
  - Poppenheim (J.), Foster's Creek.
  - Stoney (S. G.), Back River.
  - Yeaman Hall, Goose Creek.

SANTEE AREA.
- Near Columbia.
  - Guignard Brick Works.
  - Lipscomb (T. J.).
  - Jones (Wilie).
- Camden.
  - Camden Press Brick Co.

PEE DEE AREA.
- Cheraw.
  - A. G. Kollock.
- Society Hill.
  - Darlington Brick Co.
- Mandeville.
  - Bennettsville Brick Co.
- Dillon.
  - The Moore Co.
- Mullins.
  - Mullins Lime and Brick Works.
- Latta.
  - Latta Brick Works.
- Marion.
  - Layton (D. A.).
- Conway.
  - Little (H. P.).
- Bishopville.
  - J. W. Weatherly.
  - Maxey McKinzie.
- Sumter.
  - Ryttenburg Brick Works.

The general distribution of the formations comprising these beds has been already indicated.

The extensive beds of shales extending along the Fall Line must in the course of time find favor with the brick manufacturers.

A supplementary bulletin is contemplated, to be devoted to the description of the individual deposits of clay in the Crystalline Region upon completing the examination of that section.

INDEX.